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SURVEY AND ANALYSIS OF AQUACULTURE DEVELOPMENT RESEARCH PRIORITIES AND CAPACITIES IN ASIA

by

FAO Fisheries Department
Rome, Italy

and

Network of Aquaculture Centres in Asia-Pacific
Bangkok, Thailand

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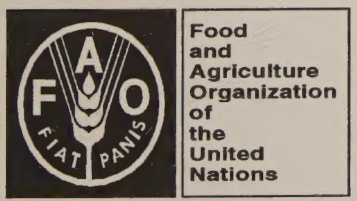

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, November 1997

PREPARATION OF THIS DOCUMENT

This document is the final version of the main discussion paper at the Regional Workshop on Aquaculture Development Research Priorities and Capacities held in Bangkok, Thailand, on 20-23 May 1997, and the report of the workshop. The workshop, and the preceding regional survey on which the discussion paper was based, were collaborative activities of the Network of Aquaculture Centres in Asia-Pacific (NACA) and the Fisheries Department of FAO. The document was finalized into its present form and content after its validation of the discussion paper by the participants of the workshop, and approval of the workshop report by participating countries.

Part I of this document was prepared by Pedro Bueno, Information Specialist and designated NACA project leader for this activity; in collaboration with other NACA staff and Dr. Ziad Shehadeh of the FAO Fisheries Department. The development of the data gathering instrument, the analysis of the survey results and the drafting of Part II of this document, including its post-workshop revision, were largely the responsibility of the consultant of the project, Ms Yong-ja Cho, with the guidance and supervision of the FAO Fisheries Department particularly Ziad Shehadeh and the supervision and collaboration of the NACA Secretariat staff, in particular, Pedro Bueno. The National Coordinators for the Aquaculture Research Survey (NCARS), who were designated by their respective governments, facilitated information collection, supplied, in most cases, the required national and institutional information, and drafted the country reports. A selection of the country reports will be published under separate cover to illustrate in greater detail and provide the local context to the range of issues highlighted by this regional synthesis.

FAO Fisheries Department; Network of Aquaculture Centres in Asia-Pacific (NACA).
Survey and analysis of aquaculture development research priorities and capacities in Asia.
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ABSTRACT

This document incorporates the outcome of two related activities: (i) a synthesis of data from a survey and analysis of aquaculture development research priorities and capacities in Asia, and (ii) the results of a regional workshop which reviewed the findings of the survey, identified themes for regional research collaboration and prepared project outlines for these themes. The synthesis includes the responses of 14 developing countries/regions in Asia to a survey of aquaculture development priorities and capacities conducted in 1996 by FAO and NACA. The information from the survey was supplemented by material provided by or published about the aquaculture development programmes of a number of international and regional organizations in the region. This document also contains the summary of survey returns from the participating countries/region among which are the major aquaculture producers in Asia and the world.

The national aquaculture development objectives and priorities are identified and matched with the research priorities and capabilities of the aquaculture sector; the analysis also points out the weaknesses in the research systems including the research priority setting mechanisms. This is followed by a description of the needs of aquaculture research and an explanation of a list of potential areas and opportunities for collaborative research at the subregional and regional levels. The synthesis also outlines the roles of governments and collaborative assistance agencies and donor organizations, as well as the private sector in regional and national research efforts.

The analysis presents a strong case for greater research attention on institutional and non-biological/technical issues in the region. One of the major observations resulting from the analysis is that planning, applying or deriving the full benefit from biological/technical research -- in which there is a great concentration of efforts -- is largely constrained by the weaknesses in the enabling mechanisms. For the overall research effort to contribute to sustainable aquaculture development, equal attention should be trained on issues associated with the socio-economic, institutional, environmental, policy, legislation and technology transfer aspects of aquaculture development.

The workshop report highlights the main outcome of discussions on the conclusions of the synthesis and presents the seven themes and related project outlines for regional research collaboration.

Abbreviations and Acronyms

AAHRI	Aquatic Animal Health Research Institute, Thailand
AARD	Agency for Agricultural Research and Development, Indonesia
AFS	Asian Fisheries Society
AIT	Asian Institute of Technology
ASEAN	Association of Southeast-Asian Nations
BAPPENA	National Policy Agency, Indonesia
BAR	Bureau of Agricultural Research, Ministry of Agriculture, Philippines
BFAR	Bureau of Fisheries and Aquatic Resources, Ministry of Agriculture, Philippines
BGD	Bangladesh
BOBP	Bay of Bengal Programme, FAO
BPPT	Study and Application Board for Technology, Indonesia
BPTP	Agency for Technology Assessment and Application, Indonesia
CIBA	Central Institute for Brackishwater Aquaculture, India
CIFA	Central Institute for Freshwater Aquaculture, India
CIFE	Central Institute of Fisheries Education, India
CIFRI	Central Inland Fisheries Research Institute, India
CMFRI	Central Marine Fisheries Research Institute, India
CPR	People's Republic of China
CRIFI	Central Research Institute for Fisheries, Indonesia
DRK	Democratic People's Republic of Korea
FAO	Food and Agriculture Organization of the United Nations
FAO/RAP	Regional Office for Asia and the Pacific, FAO
FIPIS	Fishery Project Information System, FAO, Rome
GATT	General Agreement on Tariffs and Trade
HOK	Hong Kong
ICAR	Indian Council for Agricultural Research, India
ICLARM	International Centre for Living Aquatic Resources Management
IND	India
INFOFISH	Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region
INS	Indonesia
IPFC	Indo-Pacific Fishery Commission, FAO
IRA	Islamic Republic of Iran
LIPI	Indonesian Science Institute, Indonesia
MAL	Malaysia
MOSTE	Ministry of Science, Technology and Environment, Malaysia
MRC	Mekong River Commission
NACA	Network of Aquaculture Centres in Asia -Pacific
NARA	National Aquatic Resources Research and Development Agency, Sri Lanka
NARC	National Agricultural Research Centre, Pakistan
NBFGR	National Bureau of Fish Genetics Resources, India
NCARSs	National Coordinators for Aquaculture Research Survey
NEP	Nepal
NGO	Non-Governmental Organization
NRCCF	National Research Centre for Coldwater Fisheries, India
OIE	Office international des épizooties
PAK	Pakistan
PARC	Pakistan Agricultural Research Council, Pakistan
PCAMRD	Philippine Council for Aquatic and Marine Research and Development
PHI	Philippines
RICA	Research Institute for Coastal Aquaculture, Indonesia
RICF	Research Institute for Coastal Fisheries, Indonesia
RIFF	Research Institute for Freshwater Fisheries, Indonesia
RIMF	Research Institute for Marine Fisheries, Indonesia
S&T	Science and technology
SEAFDEC/AQD	Aquaculture Department of Southeast Asian Fisheries Development Centre
SIFR	Study on International Fisheries Research
SRL	Sri Lanka
THA	Thailand
UNCED	United Nations Conference on Environment and Development
VIE	Viet Nam
WHO	World Health Organization

FOREWORD

FAO and NACA are pleased to present herewith the result of a regional study on the aquaculture development research priorities and capacities of the region. The purpose of the study was to seek ways to increase the contribution of research to the sustainable development of aquaculture so that the sector can better fulfill its roles of ensuring food security, particularly filling the growing demand for foodfish, generating productive employment and improving the income of rural people, and earning foreign exchange. An important objective was to identify key regional issues and opportunities for research collaboration among countries. An assessment and matching of national aquaculture development priorities with aquaculture research priorities, capacities and strategies gives a comprehensive overview and a fairly sharp detail of the needs of and constraints to the research sector, which in effect are opportunities for its strengthening.

The study consisted of two major activities: (i) a one-year survey, to which fourteen countries/region that include the major aquaculture producers in Asia and a number of national, regional and international organizations and programmes in Asia-Pacific had responded, and (ii) a regional workshop attended by representatives of these developing countries and organizations and programmes.

The findings confirm the primary role that governments in the region, as well as donor assistance agencies, have accorded to production-oriented research in supporting national aquaculture development. This has been accomplished largely by an overwhelming concentration and support of research effort, and necessarily of trained research manpower and other resources, in the biological and technical areas. To illustrate, over 80 per cent of the 330 aquaculture projects reported in the survey are concerned with development and research on aquaculture technologies and systems; health and environmental management; production of seed and improvement of feed and nutrition; genetic improvement and species diversification. Less than 3 per cent are concerned with the socio-economic and management aspects. Moreover, multidisciplinary studies and approaches to problem solving are rare.

The positive result of this strategy may be reflected partly by the high overall growth of aquaculture production in the region during the past fifteen years. But as the study has also noted, the task of aquaculture development research has become more challenging with the increasing number and complexity of issues attendant to national aquaculture development. As the study states, management of aquaculture has become a complex undertaking, involving all levels of governments and many disciplines, and having to also ensure harmony with other sectors that utilize the same resources.

The synopsis of national aquaculture development objectives and priorities highlighted by the survey clearly indicates that governments, while retaining their high priority on productivity, are also facing up to the need to sustain productivity gains and economic growth and to balance the emphasis on more production with more environmentally and socially responsible solutions. In retrospect, the productivity increases could have masked the weaknesses of the aquaculture research sector now being exposed by the intensifying pressure from problems other than low yield. The study lists these problems as follows: weak institutional linkages; uncoordinated planning and programming; lack of skilled human resources; ineffective technology transfer and under-utilization of information; lack of inputs and appropriate technologies for environmental and health management; pollution of the aquatic environment; and inadequate or inadequately enforced aquaculture legislation, regulations and policies. Additionally, the study notes that many of problems confronting aquaculture development have resulted from its rapid and unplanned growth, implying that the sector has not had time to build up an adequate information and knowledge base that can reliably support management decisions.

The findings provide a strong argument for research to address, along with the technical, the economic, development, environmental, legal and social issues, and for an emphasis on intersectoral, multidisciplinary and precautionary approach to the management and development of aquaculture. Lessons from the aquaculture industry in general and from some aquaculture commodity industries in particular, have made it clear that the application of technological innovations must take into account environmental and socio-economic impacts and implications. And that appropriate policies and institutional arrangements must be in place to facilitate the development and proper application of technological innovations.

In line with its objective and findings, the study outlines a strategy for tackling the common regional issues and constraints to aquaculture research. Central to this strategy is the list of research opportunities that address the issues. Of the seven research opportunities identified, three target the institutional issues, four deal with biological/technological problems. The common regional problems present an excellent scope for regional cooperation.

The study is a contribution of FAO and NACA to the follow-up of the Study on International Fisheries Research (SIFR). This presentation of its results is addressed to all the stakeholders in national aquaculture development, who have to be closely involved in the overall effort to enhance the contribution of research to development. It is principally addressed to governments and to regional and international agencies and organizations providing collaborative assistance to governments. It also makes significant references to some of the critical roles of the private and non-government sectors in improving the aquaculture research system and processes. This report updates national information on the aquaculture development objectives and priorities and the aquaculture research priorities, capacities and needs. Obviously not evenly distributed, the countries nevertheless have considerable aquaculture research capacities and resources among them that a regional cooperative activity could utilize. This regional sharing of resources to solve common problems has been effectively demonstrated by the TCDC activities of NACA which FAO and UNDP have fostered.

FAO and NACA, in line with their mandates and within the limits of their resources, will help to facilitate action on the recommendations. We envision a strategy in which governments play the central role in carrying out and managing the cooperative regional research, and sustaining the collaboration based on national research programmes rather than on the presence or absence of external support. We strongly adhere to the idea that external assistance be sought only as a means to strengthen regional cooperation and complement national efforts. In this light, regional and international organizations, including funding agencies, will appropriately act as catalyst and facilitator to regional collaborative efforts. In the ultimate, success of the total effort will depend solely on the commitment of the governments.

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Part I. Report of the Regional Workshop

1. INTRODUCTION

1.1 Background and objectives

The workshop of the study, Survey and Analysis of Aquaculture Development Research Priorities and Capacities, was organized by FAO and NACA and held at the SEAFDEC-NACA headquarters on 21-23 May 1997. The objectives of the study, in which 14 countries/region in Asia participated, was to assist in maximizing the contribution of research to aquaculture development, promote regional collaboration in aquaculture research, and focus the attention of donors and development agencies on regional research and priorities.

The overall purpose of the workshop was to formulate a regional action plan to address priority aquaculture development research issues. Specifically, it was aimed to: (i) verify and endorse the draft Regional Synthesis of the survey; (ii) identify the countries/territories that were interested in participating in specific regional and sub-regional collaborative research activities, and prospective participating organizations and groups including government R & D institutions, private sector research institutes, non-government organizations, farmer associations; (iii) prepare project concepts for the collaborative research activities; and (iv) recommend key follow-up actions to implement collaborative research activities including the roles of national institutions and collaborating regional and international agencies and organizations.

1.2 Attendance

The workshop was attended by 10 of the 14 countries/region which participated in the Survey as well as seven regional and international organizations other than FAO and NACA, and one group from the private sector. Representatives of the following countries, organizations, institutions and programmes attended the workshop: Bangladesh, China, India, Indonesia, Iran, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam, the Aquatic Animal Health Research Institute (AAHRI), SEAFDEC Aquaculture Department, AIT, FAO, FAO/RAP, ICLARM, Mekong River Commission, Shrimp Culture Research and Development Co. Ltd., Southeast Asia Aquatic Disease Control Project (SEAADCP), Danish-SE Asia Collaboration in Tropical Ecosystems Research and Training Project, and NACA. The list of participants appears as Annex 1.

1.3 Programme

Opening ceremony. The NACA Co-ordinator Hassanai Kongkeo and Dr Ziad Shehadeh of the FAO Fisheries Department welcomed the participants and gave the messages of NACA and FAO, respectively. Dr Kitjar Jaiyen, Deputy Director General of Thailand's Department of Fisheries and Chairman of the NACA Governing Council was keynote speaker.

Mr Hassanai said the outputs of the study are essential in guiding NACA's regional programme which has since evolved from a mainly bio-technically oriented development to one that places emphasis on sustainable development in consideration of the environmental and social issues. It will also help NACA's initiative to further strengthen the network. He thanked the governments, the partner organizations and FAO for continuing to provide collaborative assistance to NACA.

Dr Shehadeh emphasized that sustained growth of aquaculture is only possible with continued investment in research. He said the need for research now is greater than ever with aquaculture being called upon to make up or at least reduce the expected shortfall in food fish supplies, and this in the face of increasing competition for resources, rising input costs and more exacting market standards. Furthermore, there are pressing issues of sustainable development that must be addressed if current production levels are to be maintained, let alone expanded. Much of the basic information required to deal with these issues is lacking and must be generated through well focused research.

He believed it is appropriate that special attention be given to the identification of development issues and constraints, the clarification of the role that applied research can play in resolving these constraints, and the identification of opportunities for regional co-operation in research on issues of common concern. This is the overall objective of the current NACA-FAO survey and workshop, which was preceded by similar FAO efforts in Sub-Sahara Africa and in Latin America and the Caribbean, he informed the workshop. He said the outcome of the study will be of value to FAO Members in the region, the FAO Fisheries Department and regional office (RAP) and to NACA in the planning of future collaborative research activities in the region, as well as to bilateral and other international agencies.

Dr Kitjar Jaiyen said that aquaculture development in recent years has been impressive contributing well to food security and to the overall social and economic development. With its rapid development and increasing economic importance, the aquaculture sector has attracted more attention, a blessing and a burden, he remarked, explaining that while technology has developed rapidly, the other components -- such as legislation, policies and institutions -- which are needed to support and guide the rapidly expanding sector have not been adequately developed. He stressed that the management of sound aquaculture has become a complex task and that problems associated with sustainable aquaculture development, including the need to avoid conflicts with other sectors, demand interdisciplinary strategies. He pointed out that the aquaculture sector has yet to find an effective and successful multi-sectoral approach to its management -- an important task especially that aquaculture is situated in what is often called a grey area between agriculture and fisheries.

The NACA Council Chairman said the issue to consider carefully is on the type of research that will more effectively address national and regional problems. He said that experiences show that market forces, government policy, and social forces have strong influences on the management of sustainable aquaculture. In addition, there is also the concern over under-utilization of research outputs. Hindsight now shows that gains in production could be more than offset by erosion of the resource base and disruptive conflicts among common users, as well as other negative factors, that include threats on the marketing and trade of aquaculture products. He noted that little attention has been paid to these issues in the past.

Emphasizing the need for balance among research functions, he said that while research must continue to respond to the technical needs for increasing production in light of the continuing priority placed on higher production in government programmes, there are also the social and policy related problems of food security, poverty, sustainable resource management and utilization, and environmental protection that research must urgently tackle.

On improving capacities, he noted that governments are normally faced with the problem of scarce resources. This, coupled with declining donor support for fisheries research, makes it imperative for research efforts to be very focused and problem-oriented, relevant to issues, and cost-effective. It must also harness the combined resources of public and private institutions. In the context of regional collaboration, the NACA Chairman said that while research is basically a national responsibility, countries benefit much from regional collaboration even as regional co-operation draws on the collective strength of countries, and engenders the political will that can push research to the forefront of national development priorities.

The background, purposes of the study and objectives of the workshop were described by Pedro Bueno, Information Specialist and designated co-ordinator of the study for NACA. He also explained the workshop agenda. The salient features of the workshop include both plenary and working group sessions. Three working groups were constituted to discuss and formulate recommendations on the identified research issues and opportunities for regional collaboration. *The workshop programme appears as Annex 2.*

2. REGIONAL SYNTHESIS

The result of the survey and analysis, reported in the Regional Synthesis, that had been previously forwarded to participants and governments, was presented by the project consultant, Ms Yong-ja Cho. The survey and analytical methodologies and limitations of the study were described and its findings and conclusions explained. The discussion focused on the constraints to development and to research, priority lists of national aquaculture development, national aquaculture development research, existing research efforts and research personnel, and the opportunities for regional collaboration with the view of verifying them with the national participants. .The salient conclusions based on the Synthesis include the following:

The main technical constraints to development include lack of technologies for nutrition and feed development, genetic improvement, breeding and seed production, health and environmental management, and integrated and intensive fish farming systems. The key non-technological issues and constraints were weak interagency and institutional linkages, poor co-ordination among agencies, ineffective technology transfer and utilization, ineffective information exchange and dissemination, lack of skilled personnel, lack of understanding of impacts and implications of aquaculture development policies and plans, inadequate legislation and regulations specific to aquaculture, weak enforcement of regulations, low support for aquaculture in general and lack of support for aquaculture research in particular.

Collectively, the countries have a considerable number of research institutions with aquaculture development research programmes, research personnel and on-going research projects. Most of the research personnel specialize in the biological sciences.

Current development research priorities and research efforts of the countries address constraints to aquaculture development, focusing mainly on technical areas. Despite the serious hindrance caused by issues related to institutional and management aspects of aquaculture research and aquaculture development, these issues are largely neglected in current research priorities and efforts ; i.e., less than three percent of reported on-going research projects deal with such issues as co-ordinated planning, interagency linkages, technology utilization, socio-economic and environmental impacts, and implications of policies and management interventions.

Appropriate policies and institutional arrangements are essential to facilitate and support targeted research and desired benefits from technological innovations. The need to address non-technical issues has been noted by previous studies, including the Study of International Fisheries Research (SIFR) carried out in 1989-90, but little progress has been made on this area.

After a lengthy deliberation of the list of development and research constraints and the opportunities for regional collaboration, which include technical and non-technical topics, the workshop noted that the development of aquaculture is as much constrained by institutional or non-technical issues as bio-technical issues. It was therefore suggested that the workshop give due consideration to both institutional and bio-technical constraints in its deliberations, including the identification and selection of collaborative regional activities. This suggestion was in line with the perceived urgent need to generate knowledge and develop tools to support management decisions and to help build an enabling environment for the effective conduct of research and the application of their results.

It was also noted that while the need for systems research is becoming more widely accepted , the interdisciplinary research efforts required for this approach have not progressed very far. Bilateral and international assistance to accelerate the transition, through training on the planning and management of interdisciplinary research and pilot projects, would be very timely at this juncture.

3. SUMMARY OF COUNTRY STATEMENTS

Following the presentation and discussion of the Regional Synthesis, country representatives gave summaries of their respective country reports. The country presentations highlighted (i) national aquaculture development research needs; (ii) constraints and issues in national aquaculture development; (iii) constraints and issues in aquaculture development research; and (iv) a brief description of the aquaculture development research capacity of the country. While providing further insight into these topics, the national presentations confirmed the key constraints, needs and priorities in research and development as reported in the Regional Synthesis. The edited country reports will be published by FAO and NACA in a separate supplement at a later date.

4. IDENTIFICATION OF REGIONAL COLLABORATIVE RESEARCH OPPORTUNITIES

The discussion focused on the identification of key issues and topics for collaborative regional research. This was done on the basis of the ranking, by national representatives, of the priority needs and issues suggested in the Regional Synthesis and the country reports. The factors considered in ranking the areas for regional research included: national development needs; issues and constraints in planning and managing aquaculture development and research; existing research efforts that address the needs, issues and constraints; national capacity for research; national interest to participate in regional collaborative research; and potential benefits from collaboration. The topics were then prioritized on the basis of the number of countries assigning priority to each topic. The result of this exercise is shown in Table 1 below.

Table 1. Prioritized list of collaborative research areas prepared by country representatives

Collaborative Research Areas	No.[1]	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Priority 6 or lower
Feed and fish nutrition	8	PAK	BGD; IND	INS; IRA	CPR	THA	PHI
Health management	7	BGD; CPR; VIE		THA	PAK; IRA	INS	
Breeding and seed production	6	THA	CPR; INS; PAK	BGD; VIE			
Technology transfer and HRD	6		IRA		IND; PHI	SRL	VIE; THA
Genetic improvement	4			CPR	INS; THA	IRA	
Species diversification	4	INS; IND				VIE	CPR
Environmental management	4	PHI; SRL	VIE			CPR	
Intensive use of inland waters and stock enhancement	3		THA		SRL		PAK
Socio-economic aspects	2		PHI			IND	
Identification and expansion of culture sites	1			PAK			
Policies, legislation, regulation	2		SRL				THA
Integrated fish farming	1					PAK	

The concentration on bio-technical topics was evident, partly due to the technical specialization of the participants and partly to the perception that institutional (non-technical) issues were not researchable. Some participants felt that institutional issues might be too sensitive for regional collaboration, as

[1] Number of countries assigning priority to the topic

institutional matters and management systems are purely national concerns. However, after considerable debate, the majority felt that regional collaboration on this topic was warranted by common needs in non-sensitive general areas, such as the strengthening of national capacities in aquaculture planning and management, and in system-oriented research, as well as for facilitating information delivery and utilization within the region.

In narrowing the list to seven collaborative regional activities, the participants deleted "Genetic Improvement", which received high priority, due to the existence of a major international research effort -- the ICLARM-managed INGA (International Network on Genetics in Aquaculture), to which many of the countries participating in the current workshop belonged, and which was open to membership by others. "Species Diversification", "Intensive Use of Inland waters and Stock Enhancement" and "Breeding and Seed Production" were collated as "Seed Production and Broodstock Development for Aquaculture and Fisheries Enhancement"; "Technology Transfer" was included in a broader category entitled "Information Dissemination"; and institutional topics, other than information, were pooled under one heading "Planning and Management of Aquaculture Research and Development".

Although bio-technical topics for regional collaboration were presented in a disciplinary format, it was recognized that many of the technical issues were inter-related and research should be based on a systems approach, which is interdisciplinary in nature and is only now being applied to aquaculture. The participants therefore included an additional topic for capacity building in this type of research, particularly as applied to the development of rural aquaculture, entitled "Aquaculture Research for Rural Development". Accordingly, the proposed topics for regional collaboration, for which project concept papers could be formulated, and the number of countries subscribing to them, are shown in Table 2.

Table 2. The final list of priority areas for regional collaboration, as amalgamated from Table 1.

Collaborative Research Area	Number of Countries
A. Bio-technical	
1. Nutrition and Feeds for Aquaculture	8
2. Seed Production and Broodstock Development for Aquaculture and Fisheries Enhancement	8
3. Aquatic Animal Health Management	7
4. Environmental Management of Aquaculture	4
B. Institutional	
1. Information Dissemination (& HRD)	6
2. Planning and Management of Aquaculture Research and Development	5
3. Aquaculture Research for Rural Development	5

5. FORMULATION OF PROJECT CONCEPTS

Three working groups, each composed of representatives of countries and organizations -- the latter acting as resource persons --identified key issues related to each of the identified topics , directions for regional collaboration, and targeted achievements or outputs from the collaboration. It was agreed these would be the basis for formulating project concept papers for the identified topics. Subsequently, the concept papers would be used to formulate specific project proposals. The results of the working group exercise are shown in Table 3.

Table 3. Guidelines for the preparation of project concepts

Area	Issues	Directions for regional collaboration	Targeted achievement
1. Nutrition and Feeds for Aquaculture	Availability of quality feeds for semi-intensive and intensive culture systems to enhance existing production levels. 3. Acquiring basic knowledge of nutritional requirements for major cultured species 4. Availability and high cost of animal protein ingredients.	1. Guidelines for feed development and quality control 2. Feeding practices/strategies to maximise utilisation of feed and to minimise effects on water quality 3. Low cost far made feeds from locally available ingredients 4. Substitution of animal feedstuff with locally available plant feedstuff to develop efficient and cost-effective feeds. 5. Nutritional requirements of major culturable species	1. Improved quality and environment friendly low-cost feeds 2. Improved knowledge of nutritional requirements of cultured fish species as basis for feed formulation 3. Establishment of data base of regional feed source 4. Trained researchers, technicians and progressive farmers 5. Information network to link researchers in the region
2. Seed Production and Broodstock Development for Aquaculture and Fisheries Enhancement	1. Shortage of quality seed for aquaculture and stock enhancement 2. Lack of breeding and mass seed production techniques for some culturable species 3. Inadequate knowledge of breeding techniques for and rehabilitation of endangered species in natural waters.	1. Broodstock development and improvement of major cultured species 2. Development and improvement of breeding and mass seed production techniques for wild stock enhancement 3. Hatchery and nursery operation and management.	1. Improved techniques for broodstock development and seed production 2. Conservation and rehabilitation of endangered stocks in natural waters through stock replenishment. 3. Introduction of certain species and breeding technology in interested countries. 4. Training of researchers, technicians and progressive farmers.
3. Aquatic Animal Health Management	1. Lack of healthy (shrimp/fish) seed. 2. Limited capacity for diagnosis, prevention and treatment of aquatic animal diseases. 3. Lack of basic information on host-pathogen-environment. 4. Lack of systems/epidemiological approaches in health management. 5. Increasing transboundary movement of aquatic animals leading to spread of serious pathogens.	1. Evaluation of disease resistance improvement with breeding programmes. 2. Disease prevention and control strategies, inc. defence mechanisms. 3. Hatchery and grow-out health management strategies based on systems approaches. 4. Co-operation in quarantine/health certification[2]	1. Seed of assured quality. 2. Improved productivity of culture systems/reduced environmental impacts. 3. Reduced use of chemicals. 4. Trained personnel and diagnostic facilities. 5. Diagnostic techniques (esp. rapid diagnosis). 6. Database/information on pathogen status/disease research results. 7. Guidelines on pathogen risk reduction
4. Environmental Management of Aquaculture	1. Lack of capacity (govt/community/farm level) for effective environmental management of aquaculture. 2. Lack of appropriate institutional and policy/legal framework for responsible aquaculture	1. Systems oriented research case studies on specific culture systems/environments to assess problems and develop solutions to environmental problems. 2. Guidelines for institutional and legal	1. Quantification of environmental impacts of aquaculture (inc. social and economic dimensions) 2. Methods for developing solutions to environmental problems (e.g., effluents, social

[2] Pipeline FAO/NACA/ Regional Project on Quarantine and Health Certification Strategies

Area	Issues	Directions for regional collaboration	Targeted achievement
	(and difficulties in enforcement of existing legislation). 3. Need for more sustainable integration of aquaculture into coastal and inland resource systems (part. coastal land, and inland waters). 4. Need for low impact aquaculture technologies.	arrangements. 3. Development of farm environmental management systems, including approaches for maintaining culture environment, and reducing external impacts. 4. Environmental requirements of culture species. 5. Technology development (e.g., water recycling, effluent treatment). 6. Sharing information/training on successful/unsuccessful approaches to environmental management.	issues) and guiding responsible development. 3. Trained people in systems approaches to environmental management. 4. Improved institutional arrangements involving local people and govt (e.g., co-management). 5. Low impact (ideally positive impact) farming systems. 6. Increased efficiency of water resource use. 7. Database/information exchange system. 8. Codes of practice for farm management. 9. Reduced social and environmental problems/more sustainable development.
5. Information Dissemination	1. Ineffective technology transfer 2. Lack of appropriate methods and mechanisms for information delivery and sharing within the region.	1. Development and/or adaptation of methods and mechanism to facilitate effective technology transfer 2. Establishment of regional information system	1. Strengthened national and regional information delivery and sharing systems 2. Packaged information in various forms for different end-users 3. Trained information specialists
6. Planning and Management of Aquaculture R & D	1. Weak institutional and organisational linkages, co-ordination and collaboration among related national agencies and programs 2. Inadequate consultation with planners, implementors and users of research outputs 3. Inadequate information for planning	1. Policy and strategies for improved interagency linkages 2. Case studies on problems resulting from poor co-ordination (e.g. South Iran-shrimp culture; Gulf of Thailand; Cirata Lake and Laguna de Bay) 3. Cost-effective methodologies /guidelines for survey and assessment of existing aquaculture systems (for productivity and sustainability) and underutilized aquaculture resources 4. Training of planners	1. Improved understanding of potentials and constrains in aquaculture Improved planning capabilities 2. Improved interagency co-ordination Improved national development planning.
7. Aquaculture Research for Rural Development	1. Improper identification of research issues. 2. Poor uptake of research results	1.Introduction of farming systems research and extension methodologies in rural aquaculture. 2.. On-job training at selected pilot project sites 3.Institutionalisation of systems approach in national research systems	1.Improved research methodologies and development approaches which involve partnership with farmers and local government units (LGUs) and NGOs

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 General

Following discussions on ways and means of achieving the stated objectives of the study and workshop, participants arrived at the following conclusions and recommendations.

The workshop noted that aquaculture research had significant potential to contribute to social and economic development goals. This potential has not been realized due to various constraints many of which were highlighted in the study and by the workshop. Institutional strengthening and changes in institutional arrangements for aquaculture research may be required to increase the impact of research and its contribution to national development. The participants recommended that national priority be given to strengthening research capacity, and that well-targeted external assistance could effectively supplement national efforts to re-orient aquaculture research programmes to maximize their impact on national development.

It was noted that management of aquaculture has become a complex task, involving all levels of government and many disciplines and thus a concerted effort is required to build up tools and knowledge bases that will enable the sector to address economic, environmental, legal, social as well as technical issues. There is a need to further emphasize intersectoral, multidisciplinary and precautionary approach to management and development of aquaculture.

6.2 Action on the Workshop Report

The workshop stressed the urgency for practical follow up on workshop recommendations. In this regard, it recommended that the workshop report including the project concepts be finalized and circulated as soon and as widely as possible.

6.3 Action on the Project Concepts

The workshop recommended that FAO and NACA take responsibility for the developing and finalizing the project concepts for the identified areas of regional collaboration. The project concepts should be circulated to Governments, along with the workshop report, to indicate their interest and participation in specific regional projects. The drafts of the seven (7) project concepts are attached herewith as Annex 3.

A number of modalities for regional collaboration was discussed, with preference given to networking. The workshop recommended that existing network mechanisms (i.e. NACA, INGA, etc.) be used in project implementation and that technical lead centres be identified, as necessary, to complement existing NACA lead centres.

The workshop recommended that FAO and NACA bring the workshop recommendations to the attention of their regional bodies/Governing Council for consideration in the elaboration of their programmes of work. It was noted that the first meeting of the Aquaculture and Inland Fisheries Committee (AIFIC) of the FAO Asia Pacific Fisheries Commission in November 1997, and the NACA Governing Council Meeting in December 1997 present early opportunities for this purpose.

Concerning the participation of national bodies (including non-government organizations, private sector, and farmer groups) in the regional projects, the workshop agreed that this will be up to the national governments, depending on the nature and requirements of each project. In this regard, the workshop noted that the participation of the appropriate private sector and non-government entities would strengthen research efforts and therefore should be encouraged.

In connection with the sustainability of collaborative activities, it was agreed that national commitment was essential and that follow up should not be predicated on external support. Support should be sought to strengthen on-going efforts, rather than to initiate activities. It was further noted that regional actions do not replace or duplicate national actions and efforts; rather, they support national efforts under a regional scheme. Governments were therefore encouraged to address key issues identified at the workshop within the limits of their resources.

6.4 Regional/International Collaboration

In line with the recommendation to use existing mechanisms as well as the need to link with related regional/international programmes, the representatives of the regional and international bodies expressed willingness to participate in and support the follow-up activities that are within their respective programmes. The workshop noted the expressions of support, which should be duly considered in the formulation of the project proposals. It was further suggested that the concerned regional and international agencies could take initiative and assist with the implementation of the national programmes that are within their mandate or areas of interest.

7. CLOSING ACTIVITIES

Dr Rukhsana Anjum of Pakistan thanked the conveners on behalf of the government participants. She thanked FAO and NACA for the opportunity to take part in the study and workshop which she described as a very timely priority activity for Pakistan and, clearly, from the survey findings and workshop discussions, for the region. She reiterated government commitment and support to regional collaboration and urged a rapid follow-up of the recommendations.

Mr Pedro Bueno thanked the national co-ordinators for their inputs into the study and workshop, the representatives of other organizations for their contributions to the workshop as well as in the regional survey, the project consultant Ms Yong-Ja Cho for her excellent assistance to FAO and NACA , and to Dr Ziad Shehadeh of FAO for his guidance of the study. He thanked the chairpersons and moderators of the various sessions for effectively guiding the deliberations.

Dr Ziad Shehadeh, on behalf of FAO, thanked the country representatives and those from other organizations for contributing to the successful implementation of the study. He reiterated FAO's appreciation to NACA for carrying out the study and thanked the Co-ordinator and the staff for organizing the workshop.

The NACA Co-ordinator, Mr Hassanai Kongkeo, closed the workshop with a word of appreciation to those involved in the study and workshop and assured of NACA's active follow up of the recommendations. He wished everyone a pleasant journey home.

ANNEX 1

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ANNEX 2

Workshop Programme

20 May 1997, Tuesday

Arrival of participants: *Accommodation at the Maruay Hotel*

21 May 1997, Wednesday

08.00 **Registration**

08.30 **Opening Activity**

- Opening Remarks: NACA Coordinator
- Words of Welcome: FAO Representative
- Keynote Speech: Chairman of the NACA Governing Council

08.45 Break

09.00 **Start of the Workshop:**
Chairman: Hassanai Kongkeo

09.05 **Workshop Programme and Objectives by NACA and FAO representatives**
A brief session devoted to clarification of the Workshop Programme will follow the presentation.

09.15 **Presentation of the Regional Synthesis and Discussion of the Regional Report Project Consultant.**
The discussion will be limited to the clarification of certain aspects of the report as may be necessary. Detailed discussions on the findings and recommendations will be done by the Working Groups.

10.00 Break

10.30 **Country Reports:**
Chairman: R. Platon
Rapporteur: M.V. Gupta

10-minute presentation and 5-minute discussion; Summaries of the reports will be presented that highlight the following status:

- national aquaculture development research needs in priority order
- constraints and issues in national aquaculture development
- constraints and issues in aquaculture development research
- development research capacities

Bangladesh
China
India
Indonesia
Iran

12.00 Lunch Break

13.30 *Resumption of Country Statements*

Pakistan
Philippines
Sri Lanka
Thailand
Vietnam

15.00 Break

16.00
- Identification of common issues and concerns (institutional issues and technical priorities)
- Setting priorities to regional research needs
- Identification of national interests in regional/sub-regional research activities

Moderator: **Y. J. Cho**
Rapporteur: **M.J. Phillips**

17.00 **Arrangements for Working Group Sessions (WGs)**
The objectives and tasks of the WGs will be discussed, composition, timetables, venues, and other organizational issues will be clarified and finalized.

18.00 Brief Meeting of Working Group Leaders

18.15 End of Day One
19.00 Dinner Reception at Bangbua Restaurant

22 May 1997, Thursday

08.30 **Reiteration of Working Group session objectives and tasks**

08.45 **First Session of the Working Groups (WG)**
- Formulate project concept papers (an outline and example will be provided)

09.45 Break

10.00 continue with WG sessions

11.00 *Progress report on 1st WG session by WG Leaders*

12.00 Lunch Break

13.30 ***Second session of Working Groups***

14.45 Break

15.00 *Continue Working Group sessions*

16.00 **Presentation and Discussion of Working Group reports by WG Leaders**

17.30 End of Day Two

23 May 1997, Friday

09.00 **Plenary:** Recapitulation of Day Two Proceedings

09.30 **Plenary:** Discussions and Formulation of Recommendations

Chairman: **To be selected**
Rapporteurs: **P.Bueno**
M.J. Phillips
D. Kumar

10.30 Break for drafting of the Report

12.30 **Lunch**

13.30 *Continue Report drafting; Reproduction of the Report*

15.00 **Adoption of the Workshop Report**

17.00 *Closing Activities*

24 May 1997, Saturday

Departure for home countries

ANNEX 3

DRAFT PROJECT CONCEPTS

The regional projects outlined in the following summary concept papers are based on the guidelines formulated by workshop participants for the development of regional collaborative programmes on the seven (7) selected thematic topics. The targeted achievements and activities are only indicative at this stage and represent the combined needs of the region under each thematic topic. As objectives, they are generally too ambitious for any single project. The focus of each regional project therefore will be narrowed down, in consultation with participating governments, at the project formulation stage, taking into account current and pipe-line projects on the same theme.

As recommended by the workshop, the regional programmes will be implemented by networking, using existing mechanisms (NACA, INGA, etc.), supplemented with other technical lead centres as necessary. Depending upon national priorities, available manpower, infrastructure and research facilities, the participating Governments may wish to select one or several components of each project.

Project Concept 1

1. Nutrition and Feeds for Aquaculture

Justification

In Asia, the continuing expansion of aquaculture production areas and the need to achieve higher yields in existing production areas (i.e. intensification) have created a great demand for aquaculture feeds. A large proportion of foodfish produced in developing countries in Asia are non-carnivorous species (carp, tilapia, milkfish and others) which are grown mostly by small farms. These farms require farm-level technologies that will help them increase production with little adverse impact on the environment, using locally available feed resources to the extent possible. Similar objectives are crucial to the profitable and sustainable farming of carnivorous finfishes as well as shrimp -- which in Asia are grown to increase farm income and to earn foreign exchange.

The sustainability and profitability of commercial aquaculture operations depends largely on feeds. In the case of intensive systems, feed makes up over 50 percent of operating costs; profitability of semi-intensive systems also depends much on the efficiency of supplemental feed and natural food utilization. For either system, the critical factor for economic performance is optimising the nutritional quality of feeds through efficient use of available resources. This requires knowledge of the nutritional requirements of the species, which determines feed formulations for the species as well as the feeding strategy.

FAO's Code of Conduct for Responsible Fisheries and the ADB/NACA Aquaculture Sustainability Action Plan emphasize the importance of feed management and nutrition in environmentally sustainable aquaculture, and encourage R & D activities that aim at replacing fish meal with plant-origin ingredients, developing optimum feed management practices that improve FCR and reduce risks of feed-related water pollution, and use of locally available ingredients. The proposed co-operative research programme will be focused to address one or more of these areas; potential target achievements and activities are indicated below.

Objectives and Indicative Outputs

Development objective: An environmentally sustainable and economically viable expansion of aquaculture production with low pollution and cost-efficient feed and optimal feed management for semi-intensive and intensive culture systems.

Targeted achievements:

1. Improved knowledge of nutritional requirements of main identified culture species (as basis for feed formulation)
2. More efficient and cost-effective feeds for main cultured species
3. Environmentally friendly feed formulations and feeding strategies
4. Cost-effective supplemental feed management for semi-intensive systems
5. Data base on regional feed sources
6. Information exchange system among researchers and feed technologists in the region
7. Trained researchers, technicians and progressive farmers

Target Beneficiaries:

Small farmers would benefit from the more cost-effective feed formulations and more productive guidelines for feeding management. Commercial aquaculturists would benefit largely from economical and environmentally friendly feed formulations, while other resource users would face much less threat from discharges that are polluted by uneaten feed and feed residues. Secondary beneficiaries would be the farm-made feed manufacturing sector, which could be encouraged by the results.

Main Indicative Activities

Regional collaboration would involve the following activities:

1. Analysis of technology gaps in feed and feed management
2. Research on selected key technology gaps (e.g. feeding strategies, nutritional requirements, fishmeal replacement, low cost feed from local ingredients)
3. Preparation /adaptation of guidelines for feed development and quality control
4. Survey of local sources of feed, both animal and plant origin and collation of studies on their nutritive values as well as present and potential uses in feed formulations
5. Developing training handbooks for feed technologists, extension technicians, and farmers.
6. Collation and sharing of research information on feed and nutrition of the target species
7. Establishment of a regional information exchange system for researchers and feed technologists
8. Training of researchers, technicians and progressive farmers

Participating Countries and Institutions (Indicative)

Bangladesh:	Bangladesh Fisheries Research Institute, Mymensingh; Bangladesh Agricultural University Mymensingh
HongKong, China:	Agriculture and Fisheries Deparment
India :	CIFA, the National Centre for Coldwater Fisheries; CIBA, CIFT, Central Food Technological Research Institute; CMFRI; Mangalore College of Fisheries (Univ of Agric Sciences)
Pakistan :	Departments of Fisheries Punjab and Sindh, NARC Islamabad
Thailand:	Feed quality control and development division, NICA
Cambodia :	Department of Fisheries - National Freshwater Fisheries Station; Bati Fisheries Research Centre
China:	FFRC Wuxi, YSFRI Qingdao
Indonesia:	FADC Sukabumi, BADC Jepara, Marine Culture Deve Centre Lampung, Freshwater Fisheries Research Centre Bogor, Coastal Aquaculture Research Centre, Maros
Iran	IFRTO
Malaysia:	FRI Penang, FFRC Melaka, Brackishwater Aquaculture Research Centre Johor, NAFPRE Kedah, UPM
Myanmar:	DOF
Nepal:	Fisheries Research Centres in Janakpur, Pokhara and Trisuli; National Aquaculture Research Centre in Janakpur;
Philippines:	BFAR, UP Visayas, CLSU
Sri Lanka:	NARA
Vietnam:	RIAs 1, 2 and 3 and RIMP
Other agencies:	AIT, SEAFDEC AQD Philippines, Meralco Foundation, Inc.

Resource Requirements

Existing facilities and staff of participating countries will carry out the research and related activities. However, facilities will be upgraded and equipment acquired where possible and necessary. Support will be required for regular meetings of network members, for workshops/seminars, and for training.

Duration: Medium term; 3-5 years

2. Seed Production & Broodstock Development for Aquaculture and Fisheries Enhancement[3]

Justification

The contribution of aquaculture and aquaculture-based fisheries to nutrition and food security in developing areas as well as in resource-poor rural areas is hindered by shortage of quality seed of cultured species and of commercially important fish stocks that need enhancement or rehabilitation.

The increasing practice of stocking reservoirs, floodplain lakes, and other inland water bodies, as part of rural development strategies, has created considerable demand for massive seed supplies, particularly of cyprinids. Much of this seed is extracted from wild stocks, putting pressure on wild fish stocks. At the same time, the production of seed inputs for stocking has become a major expense to Governments. There is urgent need to develop cost-effective methods for mass production of seeds of selected species, including hatchery and nursery practices, (and to document available mature technologies) to improve the economic and ecological sustainability of the practice. The enhancement of commercial fish stocks and protection of endangered species are also making demands for broodstock development and mass seed production technologies for new species. [Article 9.3.5 of the Code of Practice for Responsible Fisheries (CCRF), cited in FAO Technical Guidelines for Responsible Fisheries No. 5, *Aquaculture Development*, states that where appropriate, "states should promote research and, when feasible, the development of culture techniques to protect and enhance stocks of endangered species".]

National objectives of increasing production from aquaculture-- through intensification, expansion of areas under aquaculture production and increased efficiency in the use of resources, as well as the diversification of species to expand markets, are creating increasing demand for better quality seed and technologies for mass seed production of new species.

Meeting these demands can be facilitated by regional collaboration on research for the development and/or standardization of technology for broodstock development and quality seed production, as well as the collation and dissemination of information on mass seed production for species of concern to the region. The proposed regional collaboration on the above problem area would be in support of an objective common to many countries of the region -- confirmed by the FAO/NACA regional study of aquaculture research priorities and capacities as a common national priority -- of increasing fish production through aquaculture and enhanced fisheries by, among other means, making available cheaper and better quality production inputs; including seed.

The project is addressed directly at the problems of unreliable supply of good quality seed for culture and stock enhancement due to the lack of standardized breeding and mass seed production techniques for cultured and culturable species, and inadequate knowledge on broodstock development, breeding and fry rearing of commercially important fish species that are now being depleted or endangered. The regional collaborative approach also addresses the issues related to the adequacy of national and institutional resources, trained research manpower and communication among researchers.

Objectives and Indicative Outputs

Development objective: Adequate supply of quality seed in support of expansion of aquaculture production and enhancement of fisheries and endangered species.

[3] Genetic improvement of cultured species was of a high priority in many countries, but the workshop agreed that the subject was sufficiently covered by ICLARM through its International Network of genetics on Aquaculture (INGA)

Targeted achievements:

1. Improved, standardized techniques for broodstock development/seed production for selected species.
2. Facilitation of enhancement, conservation, rehabilitation of fishery stocks, incl. endangered species.
3. Introduction of certain desirable species and their breeding technology for diversification of aquaculture in interested countries, in compliance with the articles of the CCRF.
4. Improved capabilities of researchers, technicians and farmers in broodstock development, breeding and seed production and fry rearing techniques.

Target Beneficiaries

The intermediate beneficiaries would be the research and extension services of governments by having new or better knowledge and more effective techniques for transmission to target users. The ultimate beneficiaries are the fish farmers, hatchery operators as well as the rural communities that derive food and livelihood from aquaculture and culture-based fisheries, and conservation of endangered species.

Main Indicative Activities

The regional collaboration would basically involve the following activities:

1. Identification of information gaps and weaknesses in technology
2. Research on selected key technology gaps
3. Collation and sharing of research information on broodstock development, breeding and hatchery - nursery management techniques
4. Preparation of manuals and training and training/extension material.
5. Establishment of a regional information exchange system on seed production, including collation of research information on species of regional interest, statistics on seed production and utilization, species diversification and introductions, etc.

Participating Countries and Institutions (Indicative)

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Iran:	IFRTO
Laos:	National Aquatic Research Institute (NARI)
Malaysia:	NAFPRE; FRI Penang, FFRC Melaka, BARC Johor
Myanmar:	DOF
Nepal:	NARC Janakpur,
Philippines:	BFAR Centres (Munoz and Pagbilao);
Sri Lanka:	NARA
Vietnam:	RIAs 1, 2 and 3 and RIMP
Other agencies :	SEAFDEC AQD, MRC

Resource requirements

Existing staff and facilities of participating centres and institutions will carry out the research activities although technicians and skilled farm labour may need to be contract-hired. Facilities will be upgraded and equipment acquired if needed. Facilities will include: broodstock tanks and ponds, hatchery systems, and nursery ponds. Essential equipment will probably include Hach kits, power generators, water pump and circulation system, aeration system and nets and gears. Support will be needed for workshops of network members and for training activities.

Duration: Medium term (3-5 years)

Project Concept 3

1. Aquatic Animal Health Management[4]

Justification

Aquaculture is overwhelmingly concentrated in the developing world, which accounts for 87% of output by quantity, and where over the past 11 years (1984-1995) production quantity has grown at a rate of 11% per year, or 5 times more than developed countries. Apart from important low input systems, which provide low cost food and much needed animal protein for local consumption, export of high value species, such as shrimps and prawns, has in some countries helped earn foreign exchange and improve their balance of payments position. However, the progress of aquaculture has been slowed by diseases, one of the most serious constraints in the Asian region to securing more food and farm income from aquaculture. Recent outbreaks of fish epizootics such as epizootic ulcerative syndrome (EUS) and crustacean diseases such as white spot, have caused serious economic losses to farmers throughout the region. The losses in 1990 alone were estimated as US$ 1.4 billion, but the situation continues to deteriorate with 1994/95 losses estimated at US$ 3.0 billion.

There are also serious "downstream" effects (e.g. increased use of drugs and chemicals, and related potential hazard to consumers; negative impact on trade and the environment, etc.) which compound the problem. With the growing trend towards intensification of production, as well as the increasing trade in live aquatic animals and seed, the problem can be expected to increase. This will tend to heighten the concern for the sustained contribution of aquaculture to food security, unless concerted efforts are made to develop and implement appropriate aquatic health management measures. There is urgent need for regional collaboration in this regard.

The proposed collaborative regional project is intended to address a number of problems related to the prevention and control of aquatic diseases. These may include:

1. Scarcity of healthy fish and shrimp seed supplies
2. Limited capacity for diagnosis, prevention and treatment of aquatic diseases
3. Lack of basic information on host-pathogen-environment interaction
4. Lack of systems /epidemiological approaches in health management

Increasing transboundary movement of live aquatic organisms and lack of regional guidelines for aquatic animal quarantine, health certification and health management

Objectives and Indicative Outputs

Development objective: Reduction of losses from diseases and increased aquaculture production and production efficiency.

Targeted achievements:

1. Improved productivity of hatcheries/nurseries and grow out production systems
2. Development of technical capacity for mass production of disease-resistant seed
1. Reduced use of chemicals and drugs
2. Trained personnel and improved diagnostic facilities
3. Guidelines for health risk reduction
4. Database / information on pathogen status / health management and related research results
5. Improved capacity to develop disease resistant broodstock of selected species

Target beneficiaries:

Hatchery operators, farmers (small-scale and commercial) and communities deriving food and livelihood from culture based fisheries; governments (from guidelines for health management, certification and quarantine); consumers, both local and in importing countries (from reduced use of chemicals and drugs); national trade (by improved marketability of products).

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[4] Existing FAO/NACA/OIE/ACIAR initiatives under the Strategy for Aquatic Animal Quarantine and Fish Health Certification provide the basis for the proposed collaborative research.

Main Indicative Activities

1. Identification of species of top priority for the study
2. Identification of farm-level risk factors associated with disease outbreak
   Research on selected topics, such as: (a) disease resistance in the selected target species[5] (b) immune systems of the target species and development of vaccines against communicable diseases of economic importance, (c) pathogen-host-environment interactions (systems approach to health management), and (d) rapid, reliable and cost-effective diagnostic methods for screening broodstock and seed at the production points.
2. Development of general guidelines for health management at the national level
3. Development of regional guidelines on quarantine and health certification for transboundary movement of aquatic animals
4. Capacity building through training of field and laboratory staff on selected aspects of health management.
5. Development of databases/information system for sharing of information.

Participating countries and institutions (indicative)

Bangladesh:	Bangladesh Fisheries Research Institute, Mymensingh
HongKong (China):	Agriculture and Fisheries Department
India:	CIFA; CIBA; CICFRI; NBFGR; CMFRI
Pakistan:	DOF Punjab and NWFP, NARC Islamabad
Thailand:	AAHRI, NICA, Mahidol University
Cambodia:	DOF - National Freshwater Fisheries Station and Bati Fisheries Research Centre
China:	FFRC Wuxi, YSFRI, Qingdao; SCSFI, Guangdong
Indonesia:	RIFI, BADC, FADC, Marine Culture Development Centre in Lampung
Iran:	IFRTO
Malaysia:	NAFPRE; FRI Penang, FFRC Melaka; BARC Johor
Myanmar:	DOF
Nepal:	NARC, Janakpur
Sri Lanka:	NARA
Vietnam:	RIAs 1, 2 and 3 and RIMP
Other agencies:	FAO, OIE, ACIAR, AIT, SEAFDEC/AQD

Resource requirements

The regional co-operative research programme will make use of the existing facilities and staff of participating institutions for this. However, certain level of strengthening may be needed in terms of laboratory and field facilities and partial support for the purchase of supplies including laboratory chemicals and biologicals. Support will be required for regional workshops/seminars and/or regular meetings of network members, and for training.

***Duration*:** Medium term(3-5 years)

[5] Can be carried out through the INGA network

Project Concept 4

4. Environmental Management of Aquaculture

Justification

Although growth in the region's aquaculture production has been impressive, expansion and intensification of aquaculture have led to shrimp and fish disease outbreaks and given rise to certain environmental concerns. Aquaculture is being called upon to increase production to meet the demand for fish protein at a time when population pressures and economic development are increasing the pressure on the region's resource base. It is inevitable in such circumstances that more attention is given to the efficient use of resources in aquaculture and responsible environmental management. Whilst appropriate aquaculture technology and systems management can contribute to fish supply, efficient use of resources and environmental improvement, it is unfortunate that poorly planned and operated farms and use of inappropriate technology have in some cases led to localised environmental impacts and social conflicts with other coastal and inland resource users.

The FAO/NACA regional study on aquaculture research priorities and capacities has shown that governments give high priority to improving the environmental management of aquaculture. Among the common problems encountered:

1. Lack of capacity at various levels (government, community, farm level) for effective environmental management of aquaculture.
2. Lack of appropriate institutional and policy/legal framework for responsible aquaculture, including difficulties in enforcement of existing legislation.
3. Need for strategies which successfully integrate aquaculture into coastal and inland systems (particularly coastal areas, inland lakes, reservoirs and watersheds, and agricutural farming systems).
4. Need for environmentally sound aquaculture technologies.

Such problems are widely recognised in the ADB/NACA Regional Aquaculture Sustainability Action Plan and FAO's Code of Conduct for Responsible Fisheries.

Objectives and Indicative Outputs

Development objective: Improved environmental, social and economic sustainability of aquaculture.

Targeted achievements:

1. Quantification of environmental impacts of existing major aquaculture systems, including social and economic dimensions, at the national level, as an aid to policy and planning.
2. Methodologies for guiding environmentally friendly and responsible development.
3. Trained people in systems approaches to environmental management of aquaculture.
4. Improved policy and institutional arrangements for promoting environmentally and social responsible coastal and inland aquaculture development.
5. Environmentally sound technologies.
6. Increased efficiency of water resource use.
7. Identification of best management practices and code(s) of practice governing the planning and operational management of aquaculture farms.
8. Enhanced database and information exchange system for wide dissemination of management and policy information to stakeholders (farmers, resource users, governments, supporting agencies).

Target beneficiaries: The ultimate beneficiaries are aquaculture farmers, particularly the small-scale farmers. The immediate beneficiaries would include the researchers, government personnel, farmers and other stakeholders participating in the research network.

Main Indicative Activities

The regional collaboration would involve:

1. Cooperative research and information exchange on environmental management systems (EMS), including appropriate technologies and operational management strategies.
2. Systems oriented case studies on specific culture systems/environments to assess problems and suggest guiding solutions to existing social and environmental problems.
3. Development of guidelines for policy, institutional and legal arrangements for environmental management of aquaculture.
4. Collection and collation of data on environmental requirements of the major cultured species.
5. Methodologies for guiding environmentally friendly and responsible development.
6. Sharing of information/training programmes on successful/unsuccessful approaches to environmental management of aquaculture.

Participating Countries and Institutions (Indicative)

Bangladesh:	Bangladesh Fisheries Research Institute, Mymenshingh
HongKong, China:	Agriculture and Fisheries Department
India:	CIFA;CIBA; CICFRI; National Centre for Coldwater Fisheries; CMFRI; NBFGR
Pakistan :	Departments of Fisheries Punjab and NWFP, NARC, Islamabad
Thailand:	NIFI, NICA,
Cambodia:	DOF - National Freshwater Fisheries Station, Bati Fisheries Research Centre
China:	FFRC Wuxi and YSFRI, Qingdao
Indonesia:	CRIFI, BADRC, FADC, Marine Culture Development Centre in Lampung
Iran:	IFRTO
Laos:	National Aquatic Research Institute (NARI)
Malaysia:	NAFPRE; FRI Penang, FFRC Melaka, BARC Johor
Myanmar:	DOF
Nepal:	NARC Janakpur,
Philippines:	BFAR Centres (National Inland Fisheries Research Center, Tanay; National Fisheries Research and Development Center, Dagupan City)
Sri Lanka:	NARA
Vietnam:	RIAs 1, 2 and 3 and RIMP
Other agencies :	AIT, AQD, ICLARM, MRC

Resource Requirements

Participating institutions and countries would provide project staff and administrative support, including operating cost at national level. Some countries may require external support for some aspects of national activities. Additional resources would be required to support activities at regional level, e.g., development/establishment of project methodologies, project co-ordination, including consultation and management meetings, training, preparation of manuals/reviews and training materials, and dissemination of project outputs.

Duration: Medium term (3-5years)

5. Title: Planning and Management of Aquaculture Research and Development

Justification

Aquaculture is being called upon to make up or at least reduce the shortfall of food fish supply caused by static landings from capture fisheries. To do so, the sector must address a number of issues, including lack of an enabling macro-environment, inadequate development planning and management, competition for resources and the sustainability of some production systems.

Co-ordinated planning and collaboration among many agencies and organizations in both private and public sectors, including fish farmers and fish farming communities, and among development sectors is needed to address these complex issues. Filling the gaps in the information base, through research, and improving the utilization of existing information will also be necessary. Past aquaculture development research efforts in Asia and other regions have focused mainly on technical constraints to development. Although technological innovations have resulted in major increases in production, other critical components -- such as institutional and management aspects of aquaculture research and development -- which are now vitally needed to support and guide the rapidly expanding sector, have not been adequately developed. The lag in the development of appropriate policies and guidelines/legislation for the management of aquaculture research and development has resulted, in some instances, in social and environmental problems.

The survey responses of the 14 Asian countries/regions[6] (in the FAO-NACA regional study on aquaculture research priorities and capacities) showed that one of the major impediments to effective development and management of the aquaculture sector, including the planning and management of development-oriented research, is weak institutional linkages and uncoordinated planning. It was indicated that the existing processes of aquaculture development and research priority setting are not effective, thus frequently resulting in poorly targeted research. Poor utilization of research results was largely attributed to these constraints. These findings agree with the conclusions of earlier studies, and suggest a general lack of progress in addressing institutional issues. Accordingly, the proposed collaborative programme is intended to assist in addressing some of these key shortcomings.

Objectives and Indicative Outputs

Development objectives: The overall objective of this project is to strengthen national capability in aquaculture development and research management and planning.

Indicative targeted achievements:

1. Strengthened national capabilities in aquaculture research and development planning and management.
2. Improved understanding of relationships among agencies, organizations and sectors that are concerned with aquaculture development and/or compete for use of the same resource bases, e.g., land and water.
3. Guidelines and strategies that will facilitate co-ordinated planning and institutional and interagency linkages.
4. Improved information support mechanisms and contents for aquaculture planning and management.

It is expected that the project would help increase the relevance of aquaculture research programmes to national development needs, and the sustainability of aquaculture development, as well as improve the supporting information services for aquaculture planning and management.

Target beneficiaries: The direct target beneficiaries of this project are the national agencies that are responsible for development and management of aquaculture sector, and the agencies that are responsible for aquaculture development research planning and management.

[6] Bangladesh, China, Korea DPR, Hong Kong SAR, India, Indonesia, Iran, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam

Main Indicative Activities

Project objectives will be approached through training, case studies and the development of guidelines and tools to facilitate development and research planning and management. Activities will include:

1. Training of planners on: (i) methods utilized in the planning, prioritization and management of development-oriented research in support of development plans; and (ii) procedures for the assessment of development potential and constraints (i.e. sector studies);
2. Case studies to: (i) illustrate weaknesses in existing planning and management processes and examine options for more effective strategies; (ii) analyze functional relationships and flow of information among agencies and sectors that participate in planning and management of research and development; and (iii) determine the adequacy of information and information services in support of planning and management, and suggest means for their improvement;
3. Reviews and studies of information needs to facilitate planning and management of aquaculture research and development, options/strategies for establishing cost-effective information services as needed; and
4. Preparation of tools/guidelines (e.g. on sector study, sustainability indicators for aquaculture, etc).

Participating Countries and Institutions (Indicative)

Bangladesh:	Bangladesh Fisheries Research Institute, Mymenshingh
HongKong, China:	Agriculture and Fisheries Department
India:	CIFA;CIBA; CICFRI; National Centre for Coldwater Fisheries; CMFRI; NBFGR
Pakistan:	Departments of Fisheries Punjab and NWFP, NARC Islamabad
Thailand:	NIFI, NICA,
Cambodia:	DOF - National Freshwater Fisheries Station
China:	FFRC Wuxi and YSFRI Qingdao
Indonesia:	CRIFI, BADRC, FADC, Marine Culture Development Centre in Lampung
Iran:	IFRTO
Laos:	National Aquatic Research Institute (NARI)
Malaysia:	NAFPRE; FRI Penang, FFRC Melaka, BARC Johor
Myanmar:	DOF
Nepal:	NARC Janakpur
Philippines:	BFAR Centres (National Inland Fisheries Research Center, Tanay; National Fisheries Research and Development Center, Dagupan City);
Sri Lanka:	NARA
Vietnam:	RIAs 1, 2 and 3 and RIMP
Other agencies :	AIT, AQD, ICLARM, MRC.

Resource Requirements

Participating institutions and countries would provide project staff and administrative support, including operating cost at national level. Some countries may require external support for some aspects of national activities. Additional resources would be required to support activities at regional level, e.g., development/establishment of project methodologies, project co-ordination, including consultation and management meetings, training, preparation of manuals/reviews and training materials, and dissemination of project outputs.

Duration: Medium term (3 years)

6. Aquaculture Research for Rural Development

Justification

More than 90% of global aquaculture production (1995) comes from Asia, but 70% of this production is accounted for by one country -- China. Despite its long history in the region, aquaculture remains a relatively minor agricultural activity, compared to crop agriculture and animal husbandry, in many developing countries of Asia. There is considerable room for the sustainable expansion of rural aquaculture in many countries of the region. Many farmers culture fish inefficiently and there are a large number of new entrants who could benefit from rural aquaculture as a source of food and income. But considerable research is still required for aquaculture to realize its potential contribution to rural development and to food security in rural areas.

Most small-scale farmers who culture fish, or have the potential to culture fish are crop and livestock farmers from a great variety of farming systems. To contribute effectively to increasing farm incomes, aquaculture probably needs to be integrated with other farming practices. In view of the wide range of ecological, economic and social variables which influence rural aquaculture, a localised farming systems approach to research and development is needed. However, till very recently, national research systems dominated by biological scientists have rarely assessed small-scale farming system, household needs and resources in order to place aquaculture technology in real world perspective; nor has research been carried out on the most appropriate extension messages and extension channels to widely disseminate research results. To-down (on-station) technology development and transfer, based exclusively on reductionist approaches to research, have proven to be ineffective; there is urgent need for interdisciplinary on-farm participatory research planning and implementation.

The situation has resulted in disruption of the research-development continuum, improper identification of research issues, irrelevant or poorly oriented research, and ineffective use of research results, leading to very frequent failure of development efforts.

A regional collaborative approach is required to introduce farming systems research and extension (FSR&E) methodologies to aquaculture researchers.

Objectives and Indicative Outputs

Development objective: Promotion of rural aquaculture to provide food and income for resource-poor farmers and food for low-income consumers, thereby contributing to food security.

Targeted achievements/Specific objectives:

1. Increased use of farming systems research and extension(FSR&E) methodologies in national aquaculture research systems
2. Improved capabilities of researchers in national aquaculture systems in FSR & E
3. Improved research methodologies and development approaches involving partnership with farmers, local government and NGOs

Target beneficiaries: The ultimate beneficiaries would be small-scale farmers (producers) and low income consumers. Intermediate beneficiaries would be government scientists and extension workers who would be better able to identify research issues, conduct more relevant and better targeted research, and disseminate research results to end users.

Main Indicative Activities

The regional collaboration may involve :

1. Regional workshops on national experiences in FSR & E of collaborating countries. An initial workshop to identify appropriate approaches followed by subsequent workshops to share project experiences.
2. The establishment of FSR&E pilot projects in specific areas of representative countries involving partnerships with researchers, local development agencies (district and provincial levels) and farmers.
3. On-the-job training and short course training
4. The establishment of a regional information network for FSR&E in aquaculture.

Participating Countries and Institutions

Bangladesh:	Bangladesh Fisheries Research Institute, Mymensshingh
HongKong, China:	Agriculture and Fisheries Department
India:	CIFA;CIBA; CICFRI; National Centre for Coldwater Fisheries; CMFRI; NBFGR
Pakistan:	Departments of Fisheries Punjab and NWFP, NARC Islamabad
Thailand:	NIFI, NICA
Cambodia:	DOF - National Freshwater Fisheries Station and Bati Fisheries Research Centre
China:	FFRC Wuxi and YSFRI Qingdao
Indonesia:	CRIFI, BADRC, FADC, Marine Culture Development Centre in Lampung
Iran:	IFRTO
Laos:	National Aquatic Research Institute (NARI)
Malaysia:	NAFPRE; FRI Penang, FFRC Melaka, BARC Johor
Myanmar:	DOF
Nepal:	NARC Janakpur,
Philippines:	BFAR Centres (National Inland Fisheries Research Center, Tanay; National Fisheries Research Center, Dagupan City);
Sri Lanka:	NARA
Vietnam:	RIAs 1, 2 and 3 and RIMP
Other agencies:	AIT, ICLARM, NACA, SEAFDEC AQD

Resource Requirements

Participating institutions and countries would provide project staff and administrative support, including operating cost at national level. It will be necessary to identify individuals within the national research systems with a systems perspective. Some countries may require external support for some aspects of national activities. Additional resources would be required to support activities at regional level, e.g., development/establishment of project methodologies, project co-ordination, including consultation and management meetings, training, workshops/seminars, case studies, preparation of training materials, and dissemination of project outputs.

***Duration*:** Medium term (5 years)

Project Concept 7

7. Information Dissemination

Justification

There is a voluminous amount of existing information on aquaculture technologies and research methodologies which do not reach planners, policy-makers, researchers, extension officers, educators and farmers at the time they are needed and in a useful form. This situation is wasteful of already scarce resources in that the useful application of existing information and technology, and the build up of new and better knowledge is hampered, and research efforts are duplicated.

The lack of appropriate methods and mechanisms for information delivery and sharing within the region have been repeatedly cited as two major problems that face R & D workers and information users. The hardware and application programmes are available and becoming more affordable and powerful with time. However, there is still a lack of personnel who possess the skills to use these knowledge processing and transmission tools properly, and have an adequate understanding of the problems and needs of the sector to be able to provide an effective information service to the various users of aquaculture knowledge and technology.

Political will and commitment are essential for resolving this problem. For various reasons, there has been a general lack of conviction about the value of maintaining necessary data bases and information systems, resulting in insufficient or discontinuous support to efforts in this area. Policy makers and planners must recognize that collection and effective utilization of information are necessary for achieving sound policies and planning of research and development. There is need to incorporate aquaculture information policies into national and regional aquaculture development plans and to establish/strengthen national and regional information programmes with appropriate mandates and resources.

The proposed project is intended to help increase awareness and access to aquaculture knowledge. Although this does not constitute research in the specific sense of the word, it is a basic prerequisite and major supporting service for both research and development, as can be noted from the information requirements of each of the preceding project concepts.

Objectives and Indicative Outputs

Development objective: Enhance aquaculture development through the improved utilization of existing knowledge in aquaculture and related fields.

Targeted achievements: these may include contributions to the following objectives:

1. Strengthened national and regional information delivery and sharing
2. Trained information specialists
3. Increased relevance (content and form) of information to targeted users

Target beneficiaries:

Policy makers, planners, researchers, educators, extension officers, and producers.

Main Indicative Activities

Regional collaboration may involve the following activities:

1. Determination of information needs in the context of national aquaculture programmes
2. Analysis of the functional relationships among activities involved in the planning and management of research and development programmes
3. Assessment of skill requirements
4. Training covering fields of identified expertise required for planning, implementation and management of information programmes.
5. Promotion of the use of common and compatible methods of aquaculture data and information handling in the region
6. Establishment of a regional information system
7. Development and/or adaptation of methods and mechanisms to facilitate effective technology transfer

Participating Countries and Institutions (indicative)

Bangladesh:	Bangladesh Fisheries Research Institute, Mymenshingh
HongKong, China:	Agriculture and Fisheries Department
India:	CIFA;CIBA; CICFRI; National Centre for Coldwater Fisheries; CMFRI; NBFGR
Pakistan :	Departments of Fisheries Punjab and NWFP, NARC Islamabad
Thailand:	NIFI, NICA
Cambodia:	DOF - National Freshwater Fisheries Station and Bati Fisheries Research Centre
China:	FFRC Wuxi and YSFRI Qingdao
Indonesia:	CRIFI, BADRC, FADC, Marine Culture Development Centre in Lampung
Iran:	IFRTO
Lao PDR:	National Aquatic Research Institute (NARI)
Malaysia:	NAFPRE; FRI Penang, FFRC Melaka, BARC Johor
Myanmar:	DOF
Nepal:	NARC Janakpur,
Philippines:	BFAR Centres (National Inland Fisheries Research Center, Tanay; National Fisheries Research and Development Center, Dagupan City)
Sri Lanka:	NARA
Vietnam:	RIAs 1, 2 and 3 and RIMP
Other agencies:	AIT, ICLARM, MRC, NACA, SEAFDEC AQD

Resource Requirements

Participating institutions and countries would provide project staff and administrative support, including operating cost at national level. Some countries may require external support for some aspects of national activities. It will be necessary to enlist the participation of universities that have well-developed programmes in development communications and journalism. Additional resources would be required to support activities at regional level, e.g., development/establishment of project methodologies, project co-ordination, including consultation and management meetings, training, workshops/seminars, case studies, preparation of training materials, and dissemination of project outputs.

***Duration*:** Medium term (3 years).

Part II. Regional Synthesis and Summary of the Survey Returns

Section 1. Regional Synthesis

EXECUTIVE SUMMARY

Many Asian countries look to the aquaculture sector to supplement the gap between the demand and supply in domestic fish consumption and earn more foreign exchange, and thus have intensified their efforts to increase aquaculture production. As part of the overall effort to facilitate increased contribution of research to sustainable aquaculture development and management, a study was initiated by FAO and NACA aimed at identifying research opportunities that address common concerns of countries in Asia.

The analysis of the national reports and survey responses led to the following observations:

- The main objectives of aquaculture development of the countries are to increase aquaculture production to meet demands for fish products for domestic consumption and export, and to generate income and employment opportunities. Strategies used to achieve the objectives of the aquaculture development included application of improved culture systems and technologies; supply of quality inputs, i.e., seed and feed; development of culture facilities and infrastructure; management of fish health and the environment; socio-economic assessment and interventions, identification and expansion of culture sites, intensive use of inland waters and stock enhancement, improvement and enforcement of aquaculture legislation and regulations, diversfication of culture species.

- Generally, consultative and participatory processes are followed in formulating national aquaculture development and research plans, involving government agencies at all levels, research organizations, fishfarming communities, private sector, and professional and trade organizations. Most commonly used criteria in planning are national development priorities; needs of fishfarming communities and private sector; local and provincial development needs; availability of funds, land and water resources, expertise and manpower. Although academic research institutions actively participate in the planning processes, there was no indication that the planning processes facilitate or promote participation of non-fisheries or non-aquaculture agencies and organizations, e.g., agencies and organizations in environment and industry.

- The common constraints and issues affecting aquaculture development and the priority areas in aquaculture development research of the countries are summarized in the following table.

- The aquaculture development research priorities of most countries are heavily oriented towards solving technical difficulties and/or introducing technological innovations in aquaculture production. Only a few countries give priority to research on aquaculture legislation, regulations and policies; postharvest handling; product development; socio-economic aspects of aquaculture; aquaculture engineering (e.g., design of pond, cage, pens, water recycling/circulation systems, etc.); and identification and selection, as well as expansion, of culture sites.

Issues and Constraints in Aquaculture Development	No. of countries	Priority Areas of Aquaculture Development Research	No. of countries
Institutional & Administrative Aspects			
Ineffective technology transfer	13		
Weak institutional linkages & coordination	11		
Lack of skilled technical personnel	10		
Lack of information delivery methods & mechanisms	9		
Weak enforcement of regulations & timely intervention	7		
Overlapping jurisdictions; lack of legal guidelines to avoid intersectoral conflicts	7	Legislation, regulations and policies	2
Lack of regulations on sitting, zoning, water quality effluent management	7		
Lack of skilled extension personnel	4		
Inefficient administration; lack of representation at decision making level	4		
Low support for aquaculture	3		
Insufficient or uncoordinated training/HRD	3		
Inefficient/Ineffective plans or policies	2		
Underutilization of skilled manpower	1		
Cumbersome recruitment of personnel	1		
Socio-economic Aspects			
Inadequate marketing & involvement of middlemen	6	Socio-economic assessment	3
Lack of loan support and credit assistance	6		
Low price of inland fish & demand	3		
Lack of incentives for private sector	1		
Security at culture sites & risk involved	1		
Difficulty in finding workers in aquaculture	1		
Low priority given to welfare of fishermen	1		
Technical & Environmental Aspects			
Pollution and other environmental factors	10	Environmental management	12
Effluent & water treatment; farm management	8		
Insufficient supply of quality seeds	7	Breeding & seed production	13
		Genetic improvement	11
		Species diversification	4
Lack of quality fish feeds & feed ingredients	7	Fish nutrition & feed development	11
Fish health management & pest control	7	Fish health management	11
Insufficient infrastructure, e.g., hatcheries, feed mills, storage & processing facilities, etc.	5		
Inadequate aquaculture enclosures & engineering, e.g., design of ponds, cage, pen, etc.	1	Aquaculture enclosures & engineering	3
Weak postharvest handling & product development	4	Postharvest handling & product development	3
Shortage of suitable culture sites	3	Culture sites, identification & expansion	2
Lack of survey data	1	Inland waters & stock enhancement	7
		Population dynamics & stock assessment	5
Lack of or insufficient culture technologies	2	Culture systems & technologies	14
		• Integrated fishfarming	4
		• Intensification of culture systems	4
Lack of EIA	1		

- In spite of expressed common issues and constraints related to institutional linkages and coordination, technology transfer, human resource development, and socio-economic assessment and interventions, the aquaculture research sector gives little attention to research on mobilization of available human and financial resources for sound aquaculture development and research; investigation of methods and mechanisms for improved technology transfer and information exchange; social and economic impacts of aquaculture policies; policy framework and management instruments for social equity; and research on strategies and policy requirements for improved institutional and interagency linkages and coordination.

- The research areas recommended by recent regional and international meetings and studies appear to be in line with the issues and constraints in aquaculture development reported by the survey. However, it was difficult to assess the extent to which these recommendations were used as an input in the formulation of national research programmes as countries did not indicate whether or not the recommendations of regional and international studies or meetings were considered in setting research priorities.

- A considerable number of research organizations exists in the countries, with competence to undertake research in various aspects of aquaculture, particularly in culture systems and technologies; breeding; genetic improvement; nutrition and feed formulation; and health and environmental management. The capacity to undertake research in socio-economic, policy and management aspects, postharvest handling and product development has not been clearly indicated in survey responses or national reports.

- Similarly, significant aquaculture development and research efforts are on-going in the countries, focused mainly on biological and technology oriented research. Few on-going projects (less than 3%) are concerned with socio-economic, policy, planning and management aspects. The thrusts of aquaculture research projects funded by donor agencies showed similar patterns i.e., the majority support technology oriented research.

- The countries also have a large number of research personnel. However, the majority specialize in biological sciences; few are in engineering and physical sciences, and fewer still in legal, management, monitoring and enforcement, policy, development, planning and socio-economics. This imbalance, and the reported weak institutional linkage and coordination, could explain the concentration of research priorities and efforts on technological innovation based on biological sciences and the lack of integrated approaches needed to respond to the socio-economic and environmental concerns of the sector.

- The tendency to encourage technological solutions as the means of promoting aquaculture development has overlooked the need for research on the economics, management and social dimensions of production systems and the effects of technological approaches on development.

- The private sector participates in formulating aquaculture development and research plans, but has no significant role in conducting and supporting research. The private sector derives significant benefits from technological innovation in culture technology and systems, e.g., genetic improvement, development of hatchery technologies, feeds, drugs and new products, improved packaging and handling, etc., and should be encouraged to undertake and support research with appropriate policies and incentives.

- Although consultative and participatory processes are reported to be practiced in setting research priorities, targeted or coordinated research planning, and intersectoral and multidisciplinary approaches in research and management are generally lacking in many countries. It is important to bear in mind that insufficient communication between the research community and the production sector weakens demands for and use of aquaculture research. Existing efforts in disseminating research outputs and technology transfer do not appear to be sufficient or effective in facilitating and promoting the use of technological innovation.

- Aquaculture research suffers from absence of long-term planning and inadequate funding. This does not appear to be consistent with the increasing importance given to its role in national food security and generation of income and employment opportunities in coastal and rural communities. It appears that the need for and the contribution of research to aquaculture development is not well understood by the policy makers and public.

- Aquaculture policies and regulations seem to have lagged behind technological advancement. In some instances, this has resulted in environmental and social problems and has not encouraged environmentally sound and socially responsible aquaculture. Furthermore, institutional arrangements and capacity do not appear to have adjusted to meet the requirements of the fast growing sector. The management approach is often reactive rather than proactive.

The above observations are disconcertingly similar to the findings of previous studies. For example, the shortcomings mentioned in the SIFR studies include resources spread across too many institutions; inappropriate resource allocation; poorly integrated strategies and coordination mechanisms; lack of multidisciplinary staff resource; lack of long-term funding support; low motivation; quality and relevance of training; communication gap between public sector institutes, universities and production sector; inappropriate dissemination mechanisms; top-down approaches and unrealistic demonstrations in technology transfer; and relevance and effectiveness of research outputs. The present study shows that little change in the sector management has occurred since late 1980's, except increased awareness of shortcomings and needed changes, and reactions to such external pressures as environmental degradation, social and resource (i.e., land and water) use conflicts, and stringent quality control for consumer safety.

Indicative opportunities for regional research cooperation were identified mainly on the basis of the objectives of aquaculture development and the key common constraints that emerged from the survey and national reports. Special attention was given to the need to strengthen the enabling environment, e.g., institutional arrangement and policies that foster sound aquaculture development research, assisting aquaculture managers, planners and other concerned parties in making decisions. Contrary to the general view that economic, social, legislation, policy and management issues are outside the aquaculture research programmes, or "non-researchable", it is necessary to complement research on technology with research on socio-economics. This is because technology application must take into account environmental and socio-economic implications. More importantly, appropriate policies and institutional arrangements must be in place to facilitate technology development and use.

Recognizing the existing research efforts on production technology, the available capacities for research on various technical aspects, and the knowledge gaps in addressing the common concerns in aquaculture development and management, the following areas were identified as priority research opportunities for regional collaboration:

PLANNING AND MANAGEMENT OF AQUACULTURE DEVELOPMENT AND RESEARCH

- Policies and strategies for improved participatory planning, interagency linkages and institutional arrangement for improved intersectoral and multidisciplinary coordination and collaboration
- Strategies for targeted, field-oriented and policy-relevant research
- Methods and mechanisms for improved technology transfer and information dissemination and sharing, including analysis of functional relationships between related institutions/units
- Assessment of human resource requirements and strategies for training
- Strategies for mobilizing human and financial resources for aquaculture development and research

ENVIRONMENTAL MANAGEMENT IN AQUACULTURE

- Methodologies for environmental impact assessment (EIA) of coastal aquaculture
- Siting protocols and guidelines for aquaculture zoning
- Environmental standards for aquaculture effluents and water quality
- Codes of practice for aquafarm management

SOCIAL AND ECONOMIC ASSESSMENT OF AQUACULTURE

- Methodologies and guidelines for social impact analysis
- Cost benefits of aquaculture systems
- Impacts of aquaculture development policies on food security, income and employment generation, livelihood of small-scale and subsistence fishfarmers, gender and equity
- Macro- and micro-economic policy requirements for sustainable aquaculture
- Strategies for improved postharvest handling and product development, including distribution, marketing and consumption, and relationships between producers, middlemen and consumers

LEGISLATIVE FRAMEWORK FOR AQUACULTURE

- Guidelines for application of existing laws to aquaculture
- Guidelines and strategies for formulating aquaculture legislation

FISH HEALTH MANAGEMENT

- Disease diagnosis and control methods
- Strategies for disease control and prevention
- Epidemiological assessment

FISH NUTRITION AND FEED DEVELOPMENT

- Formulation of low cost and farm-made feeds
- Feeding optimization

BREEDING & BROODSTOCK MANAGEMENT

- Culture species diversification
- Broodstock improvement

The outcome of this study does not reveal new information on aquaculture development research needs. However, it underscores the need for concerted action to strengthen management and planning capacities of the aquaculture sector and improve the enabling environment. In this context, regional collaboration would support and supplement national efforts, and help to muster the political will that institutions, acting alone, would not be able to inspire.

Action plans for regional cooperative research should be formulated and implemented on the basis of the interests and commitment expressed by the countries in the suggested themes. An incremental or step-by-step approach could be taken in the development and implementation of the regional activities. Formulation of action plans and project proposals should give particular attention to the needs for field-oriented, problem-solving and policy-relevant research, and encourage active participation of the private sector, local and fishfarming communities, and policy-planners.

Success of regional collaboration depends on the commitment of the participating countries. They must be prepared to play the central role in implementing and managing the collaborative regional research. To be sustainable, regional collaboration must be based on on-going or planned national development research programmes rather than the presence or absence of external support. External assistance should be sought as a means to strengthen regional cooperation and efforts. Therefore, the role of the regional and international organizations, including funding agencies, should be as a catalyst and facilitator.

1. BACKGROUND

Aquaculture in many parts of Asia is a traditional practice and has been an integral part of rural life. In recent years the world has witnessed a decline in the abundance of natural fish stocks. Many Asian countries regard aquaculture as the sector that must fill the gap between demand and supply in domestic fish consumption as well as a means to increase foreign exchange earnings. Thus, they have intensified their efforts to increase aquaculture production. The actions of recent years have helped to achieve the short-term goal of increased fishery production. However, the rapid expansion and what has been widely perceived as uncoordinated development of aquaculture have resulted, in some instances, in a variety of problems relating to environmentally sound and socially responsible aquaculture development and management, particularly in coastal areas.

1.1 Purposes

In the post-UNCED and post-GATT world, the issues and challenges faced by the aquaculture sector have become more numerous and complex. The aquaculture sector must address the task of increasing production while dealing with a variety of issues such as intensive competition for resources i.e. land and water; increasing cost of inputs; consumer demands for food safety and high quality products, food security; social equity; and environmental soundness. The management and development of the aquaculture sector require interdisciplinary, multi-agency and multi-jurisdictional approaches. However, much of the basic knowledge required to understand these issues and take appropriate management action is lacking, and must be generated through well formulated research.

In February 1994, FAO organized a roundtable discussion among the regional fisheries bodies, i.e., FAO/RAPA, AIT, AFS, NACA and SEAFDEC, for the purpose of initiating the preparation of a study to determine aquaculture research priorities and an action plan within the framework of the Strategy for International Fisheries Research (SIFR). The objectives of the study were to assist in maximizing the contribution of research to aquaculture development; promoting regional collaboration in aquaculture research; and focusing the attention of donors and development agencies on regional research needs and opportunities for collaboration. The roundtable discussion noted gaps in existing information, particularly at national level on aquaculture development and research priorities, and the need for active national participation in the study.

1.2 Specific Objectives

In following up the recommendations of the roundtable meeting, FAO and NACA agreed to implement the current study, with the following specific objectives:

- Collect and analyze published information on development constraints and priorities, development oriented research needs and priorities and research capacities in Asia
- Assess the extent of follow-up on current research priorities identified in various fora/bodies, and the constraints to research implementation, if any
- Identify research needs and opportunities of common concern for sustainable aquaculture, as potential focal points for co-operation at the regional and sub-regional levels
- Document existing capacities for applied research on aquaculture and suggest potential networks for the execution of identified regional and sub-regional research priorities, with supporting project concepts
- Prepare a report compiling the results of the survey, analysis and conclusions.

1.3 Methodology

The study followed the methodological guidelines agreed to by FAO and NACA, which comprised the following basic steps:

- Questionnaire survey to collect information on national aquaculture development priorities and actions; development research priorities; processes and criteria used in setting development and research priorities; issues and constraints in planning and managing aquaculture development and development research; and aquaculture development research capacities and programmes/projects.
- National report on aquaculture development research priorities and capacities prepared by the countries. The information gathered through the survey would be used as a basis for the national report.
- Regional synthesis of the survey responses and national reports, including identification of regional collaborative research opportunities on common concerns.
- Regional workshop to verify the synthesis of the regional survey, identify the countries that are interested in participating in regional collaborative research and to evolve an action plan for implementation of regional collaborative research.

1.4 Survey and Analysis

In February 1996, a three-section-questionnaire was prepared (Annex 1) and sent to twenty-two countries (through the offices of the NACA Council members or the offices that are responsible for cooperation with NACA) in March 1996. Fourteen countries responded by nominating National Coordinators for the Study (NCARSs) who facilitated the in-country surveys and preparation of the national reports (Appendix 2, List of NCARSs). The participating countries/region were Bangladesh, China, Hong Kong China, India, Indonesia, Iran, Korea DPR, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam.

At the national level, the NCARSs distributed the survey forms, accomplished some of the forms themselves and forwarded the completed survey forms to NACA. To facilitate the survey, the NACA Information Specialist who was the coordinator for the study, explained the purposes of the study and the specifics of the questionnaires at the 4th NACA Technical Advisory Committee meeting held in Islamabad in May 1996. Additionally, the NACA professional staff assisted the NCARSs during their missions to six countries, i.e., Bangladesh, India, Malaysia, Nepal, Pakistan and Vietnam.

Regional and international organizations or national institutions with regional programmes, i.e., AAHRI, AIT, Bay of Bengal Programme, FAO/RAP, ICLARM, Mekong River Commission, NACA and SEAFDEC Aquaculture Department, were requested to provide information on their programmes, capacities, and on-going activities in aquaculture, as well as issues and constraints in formulating and implementing their programmes. Three organizations responded to the request, but only one fully. Therefore, additional information on the programmes of the regional organizations was gathered from the published literature.

The survey returns that were received by the end of August 1996, were summarized for each country and the summaries sent to the countries for their review and validation in September 1996 (see Section 2. Summary of the Survey Returns). At the same time, the countries were requested to prepare a national report on aquaculture development research priorities and capacities, interpreting information presented in the summary of the survey returns. An outline for national reports (Annex 3) was provided to the countries to ensure use of common format and consistency in contents. The countries were also offered assistance in preparing national report.

By the end of December 1996, nine country reports were received, four of which were incomplete. In view of the time constraint and the need to prepare a background paper for the Regional Workshop scheduled for May 1997, a regional synthesis was prepared on the basis of available information.

The regional synthesis (i.e. Part II of this report) summarized the priorities, capacities, on-going efforts, issues and constraints in aquaculture development and development research that were articulated in the survey responses and national reports, observed gaps in research efforts in addressing issues and constraints in aquaculture planning and management, and identified opportunities for regional collaborative research on common concerns.

For the purpose of identifying gaps and concentration in research efforts, the aquaculture development priorities and actions and aquaculture research priorities and efforts were grouped by using common broad thematic headings. The research priorities and efforts were then compared with the development priorities and actions, and issues and constraints in aquaculture planning and management.

In a number of cases, survey responses were incomplete or too general, or no information was provided (Table 1). Therefore, survey responses were supplemented with information from other sources such as national reports, papers presented at recent national or regional meetings, and NACA Secretariat staff. The sources of information are indicated in footnotes in the Summary of the Survey Returns.

Some survey responses seemed inconsistent. For example, although most countries indicated existence of a number of research institutions that conduct substantial research in various aspects of aquaculture, it appears that the capacities of these research institutions were not always taken into consideration in assessing adequacy of national research capacity to meet development needs.

Table 1. National responses to the survey

Countries	Survey returns			National reports
	Section I (Development Agency)	**Section II** (Research (Coordinating Agency)	**Section III** (No. of Res. Organizations responding)	
BGD	Yes*	Yes	1	Yes
CPR	Yes	*	3	*
DRK	Yes*	Yes	*	*
HOK	Yes	Yes*	3*	Yes
IND	Yes	Yes	6	Yes
INS	Yes*	Yes	7*	Yes*
IRA	Yes*	Yes*	*	Yes*
MAL	Yes*	Yes*	1	*
NEP	Yes	Yes	6	Yes
PAK	Yes	Yes	4	Yes
PHI	Yes	Yes*	4	Yes
SRL	Yes	Yes	5	Yes
THA	Yes	*	5*	Yes
VIE	Yes	Yes	6*	Yes*

Note: * no returns or incomplete returns (no response to more than one question).

In some cases, the responses were not appropriate (e.g., cumbersome credit systems, lack of high quality feed or fish disease as the constraints in planning and managing aquaculture development research programmes) and had to be excluded from the analysis or moved to appropriate sections.

The identification of regional collaborative research opportunities took into account such factors as issues and constraints in planning and managing aquaculture development and development research; on-going efforts addressing the issues and constraints; available capacities and expertise to address the issues and constraints; importance to the sector management; and existing regional and international initiatives.

The draft regional synthesis was distributed to the countries for review and validation in March 1997, and used as a discussion paper at the Regional Workshop on Survey and Analysis of Aquaculture Development Research Priorities and Capacities, held in Bangkok on 21-23 Many 1997. The report presented here incorporates additional information received since December 1996.

1.5 Limitations

Three basic shortcomings arose from the responses, namely, (i) the survey returns were not comprehensive or complete in terms of their coverage of institutions concerned with aquaculture research, (ii) the survey responses were often too general or partially answered and (iii) not all countries replied to every survey question.

The responses seemed to indicate that the respondents considered aquaculture along the traditional zoology-based disciplines, and strictly within the programmes of their own institutions or units. Although some academic research institutions participated in the survey, it is difficult to assess the coverage of relevant research activities and programmes carried out by the institutions outside the national fisheries and aquaculture agencies.
There were considerable differences in response styles among the countries, e.g., articulation and level of details. The countries where English is commonly used tend to be more descriptive. It also appeared that different countries used somewhat different criteria to describe such aspects as key constraints, research capacities or research organizations with major aquaculture research programmes.
The difficulties and delays encountered in the survey and preparation of national reports, as well as incomplete responses or data compilation, may be symptomatic of the situation that the aquaculture sector encounters in planning and managing its research programmes. Formulation and implementation of responsive research programmes require coordination and collaboration with related institutions and programmes and an efficient flow of reliable and relevant information for management and planning decisions. If this observation is proven to be valid, the aquaculture sector will need to give immediate attention to improve accessibility and availability of information for planning and management, and coordination among related institutions and programmes.

Notwithstanding the limitations, the usefulness of the information presented in this report is to serve as an indicator rather than full description of the situation in national aquaculture sectors. It identifies some of the more critical issues and significant constraints that may be the subject of a detailed assessment. The issues and constraints can serve as the focus of collaborative research in the region.

2. AQUACULTURE IN ASIA

Asia is home of over half of the world population. It is also the major fish consuming region of the world. The survey responses and national reports highlighted that the contribution of aquaculture to fishery production, food security, employment, nutrition particularly in rural and coastal communities, and national economy is significant and steadily increasing.

Asian aquaculture has a long history and is generally considered as most developed, compared to other developing regions of the world. According to the FAO statistics

aquaculture production has increased significantly over the past 12 years, from 10.5 million metric toones (mt) in 1984 to 27.8 million mt in 1995, of which 13.7 million mt (after gutting and shelling) were fish and shellfish for direct human consumption. In 1995, Asia contributed to 90% of total world aquaculture production.

Nine of eleven major aquaculture producing countries/regions are in Asia, i.e., China, Taiwan China, India, Japan, Indonesia, Thailand, Philippines, Korea Rep, and Bangladesh. In these countries, aquaculture contributed from 13-60% of national fish production in 1995. Although it is difficult to obtain accurate statistics on employment, largely due to the integral or part-time nature of the work, the aquaculture sector is known to play an important role in generating employment opportunities, particularly in rural communities.

Asia is a major importer and exporter of fishery products, and does influence the global balance between supply and demand. FAO statistics place Asia's 1995 share of world trade of fishery products at approximately US$ 24.7 billion for imports and US$ 18.3 billion for exports.

A large number of aquatic species are being cultured in the Asian countries, using a variety of culture systems. Main aquaculture systems used in inland aquaculture are pond, pen, cage, tank systems as well as culture-based fisheries in open water bodies. Coastal aquaculture is dominated by pond, cage and pen systems, and such methods as floating, hanging, broadcast, long-line, pole, mudflat, and bottom culture of mollusc and seaweeds. Integrated farming systems; i.e. agriculture/livestock/fish, is popular in several countries such as Bangladesh, China, India, Indonesia, Nepal, Philippines, Sri Lanka, Thailand and Vietnam.

Tables 2, 3 and 4 show selected aquaculture and fisheries statistics of the countries in the region.

Table 2. Selected fishery statistics of Asian countries/regions

Country	Population[1] 1995 (million)	Total fish prod., '95 (mt)[2]	Total Aquaculture Prod. in '95 (mt)[3] Fish & Shellfish	Others	Aquaculture Value in '95 (1000 US$)[3] Fish & Shellfish	Others	Fish Supply (kg per caput)[4]	Fish /Animal (%)Protein in'93[4]
Bangladesh	120.0	1,170,365	321,506	-	595,206	-	8.8	46.7
Bhutan	1.6	340	30	-	36	-	0.2	1.6
Brunei	0.3	4,812	103	-	823	-	20.4	11.1
Cambodia	10.3	112,510	9,511	-	23,632	-	8.5	38.6
China	1,221.5	24,433,321	12,792,021	4,807,066	12,401,439	3,986,073	14.3	21.5
Hong Kong China	6.2	203,570	8,571	-	50,832	-	57.9	28.3
Taiwan China	20.1	1,288,406	277,954	8,284	1,371,655	3,532	37.1	28.9
India	935.7	4,903,659	1,608,938	-	2,138,813	-	4.0	53.5
Indonesia	197.6	4,118,000	611,410	108,000	1,851,944	11,800	4.0	12.70
Iran I R	67.3	368,300	28,500	-	297,426	-	5.3	9.0
Japan	125.2	6,757,570	820,124	585,363	4,271,660	1,581,679	67.8	47.02
Korea, DPR	27.9	1,850,000	85,450	130,500	269,638	64,150	43.6	65.2
Korea, R	45.0	2,688,o24	368,155	649,099	617,364	323,903	52.3	46.8
Laos	4.9	40,250	14,400	-	36,000	-	6.8	23.6
Malaysia	20.1	1,239,755	132,730	-	151,564	-	29.0	21.6
Maldives	0.3	104,566	-	-	-	-	144.4	89.3
Myanmar	46.5	832,469	47,255	-	667,715	-	16.0	47.6
Nepal	21.9	21,148	9,918	-	10,896	-	0.8	3.2
Pakistan	140.5	540,560	15,116	-	12,621	-	2.4	4.0
Philippines	67.6	2,269,234	346,271	466,224	1,224,928	43,985	34.4	51.5
Singapore	2.8	66	3,625	-	11,644	-	37.2	18.8
Sri Lanka	18.4	235,829	6,329	-	270,053	-	15.4	51.5
Thailand	58.8	3,501,772	464,224	-	1,894,300	-	26.5	41.1
Vietnam	74.6	1,200,000	211,400	8,000	547,810	3,600	13.3	35.0

[1] FAO (1996a)
[2] FAO (1996b)
[3] FAO (1996c)
[4] FAO (1996d)

Table 3. Import and export statistics of fish and fish products of selected Asian countries/regions (1995)[5]

Country	Import Quantity (mt)	Import Value (US$ 1000)	Export Quantity (mt)	Export Value (US$ 1000)	Net (E.-I.) Quantity in '95 (mt)	Net (E.-I.) Value in '95 (US$ 1000)
Bangladesh	46	199	32,383	220,229	32,337	220,030
Brunei	3084	6,551	192	629	-2,892	-5,922
Cambodia	-	-	23,816	14,300	23,816	14,300
China	1,324,824	941,293	679,073	2,854,373	-645,751	1,913,080
Hong Kong China	328,727	1,827,691	224,470	638,523	-104,257	-1,189,168
Taiwan China	532,645	589,723	848,753	2,328,105	316,108	1,738,382
India	7,055	8,119	425,817	1,240,603	418,762	1,232,484
Indonesia	159,056	101,104	499,066	1,666,752	340,010	1,565,648
Iran I R	97,592	76,444	11,397	55,010	-86,195	-21,434
Japan	3,481,081	17,853,481	228,431	713,219	-3,252,650	-17,140,262
Korea, DPR	1,117	2,336	62,811	77,430	61,694	75,094
Korea, R	407,320	824,817	406,177	1,564,878	-1,143	740,061
Laos	565	227	26	67	-539	-160
Malaysia	257,863	323,619	189,234	334,873	-68,629	11,254
Myanmar	-	-	26,449	79,743	26,449	79,743
Nepal	-	-	54	71	54	71
Pakistan	89	104	62,556	150,396	62,467	150,292
Philippines	396,508	134,789	127,125	502,201	-269,383	367,412
Singapore	212,693	659,681	154,700	584,594	-57,993	-75,087
Sri Lanka	61,430	58,038	5,358	56,227	-56,072	-1.811
Thailand	915,850	825,606	1,019,112	4,449,457	103,262	3,623,851
Vietnam	4,105	2,506	83,726	512,937	79,621	491,431

The countries/region in the shaded area participated in this study.

[5] FAO (1996e)

Table 4. Aquaculture production (mt) in participating countries/regions by category (1995)[6]

Country	Freshwater Fishes	Diadromous Fishes	Marine Fishes	Crustaceans	Molluscs	Aquatic Animal nei	Aquatic Plants	Total
Bangladesh	287,476	-	-	34,030	-	-	-	321,506
China	9,311,196	-	182,401	181,880	3,099,099	17,445	4,807,066	17,599,087
Hong Kong	2,958	207	5,035	-	371	-	-	8,571
India	1,512,065	-	-	96,873	-	-	-	1,608,938
Indonesia	298,800	160,440	10,000	142,170	-	-	108,000	719,410
Iran IR	13,115	500	2,130	-	-	-	-	15,745
Korea DPR	12,000	2,500	-	13,700	57,250	-	130,500	215,950
Malaysia	15,501	5,175	3,493	7,481	101,080	-	-	132,730
Nepal	9,918	-	-	-	-	-	-	9,918
Pakistan	15,048	20	-	48	-	-	-	15,116
Philippines	89,154	137,796	927	93,239	25,155	-	466,054	812,325
Sri Lanka	3,000	-	-	3,329	-	-	-	6,329
Thailand	95,157	2,702	1,066	285,718	79,530	51	-	464,244
Vietnam	150,000	61,400	-	-	-	-	8,000	219,400

[6] FAO (1996c)

3. AQUACULTURE DEVELOPMENT

3.1 Aquaculture Development Planning

The national aquaculture development plan is generally formulated within the overall framework of the fisheries development plan which is a component of the national agricultural development plan and, ultimately, the national economic development plan. Every country has a central agency, under the ministry of agriculture or fisheries, that is responsible for development and implementation of the aquaculture development plan.

The central aquaculture development agency assesses development needs through analysis of available data and consultations with key stakeholders, e.g., fisheries and related agencies both at national, provincial and local levels, national policy planning agencies, academic and research organizations, private sector, including investment organizations such as banks, and fishfarmers. The survey responses indicated that the consultation process encourages active participation of fisheries agencies and provincial and local government agencies, and the involvement of the agricultural sector (mainly because fisheries is often under the ministry of agriculture). The responses did not indicate the extent of the consultation with related sectors such as industry and environment.

Formulation of the national aquaculture development plan is reported to generally follow a consultative process, utilizing reports, workshops and meetings at national and local levels. Two approaches, bottom-up and top-down, are followed in formulating aquaculture development plans. The bottom-up approach begins with the issues and needs identified at local and field levels, while top-down approach which most of the responding countries use begins with the needs and issues identified by the central planning agencies. The priority needs are determined through consultation, taking into account the needs and interests of the various parties.

Table 5. Processes and criteria used in formulating national aquaculture development plans

Countries	Processes followed	Participating Groups	Criteria used
BGD	• no information	• no information	• no information
CPR	• Central government initiative • Consultative	• Fisheries agencies at all levels • Research & academic institutions • Extension agencies	• National development plan
DRK	• no information	• no information	• no information
HOK	• Local initiative • Consultative	• Fisheries agencies at all levels • Fishfarmers • Other related government agencies • Special interest groups, e.g., environmentalists • Research & academic institutions • Extension agencies	• Importance of the problems or issues • Availability of expertise and resources • Fishfarmers' needs

Countries	Processes followed	Participating Groups	Criteria used
IND	• Central government initiative • Consultative	• Fisheries agencies at all levels • Other related government agencies • Research & academic institutions at all levels • Extension agencies	• National development plan • Regional development needs • Local developmental needs • Availability of aquaculture resources • Fishfarmers' needs • Expected employment & income generation • Availability of funds at national, state and local levels
INS	• no information	• no information	• no information
IRA	• no information	• no information	• no information
MAL	• no information	• no information	• no information
NEP	• Central government initiative • Consultative - annual workshop	• Fisheries agencies at all levels • Other related government agencies • Research & academic institutions at all levels • Fishfarmers • Extension agencies	• Potential of aquaculture • Fishfarmers' needs • Availability of resources • Availability of technology
PAK	• Central government initiative • Consultation	• Fisheries agencies at all levels • Research & academic institutions at all level • Private investors • Donor & external agencies	• Availability of fish seeds • Interest of public and private sectors • Potentials of aquaculture resource bases • Demand for fish and fish products
PHI	• Central government initiative • Consultative	• Fisheries agencies at all levels • Other related government agencies • NGOs • Fisheries organizations • Research & academic institutions at all levels	• National development needs • Priorities identified by fishfarmers, private sector and local governments
SRL	• Central government initiative • Consultative	• National fisheries agency & its Committee of Experts • Resource personnel • Researchers • Fishermen's organizations • NGOs • Public	• Availability of aquaculture resources • Potential for increased production • Potential for income generation • Potential for foreign exchange earning
THA	• Central government initiative • Consultative	• Fisheries & aquaculture agencies • Other related government agencies • Office of fisheries technical advisor	• National development plan
VIE	• Central government initiative	• Fisheries & aquaculture agencies • Research institutes • Government and private hatcheries • Private sector	• National developmental needs, specifically national demand for seeds

The key factors considered are the priority needs identified in the national development plan, needs of local communities and fishfarmers, opportunities for employment and income generation, gaps between demand and supply of food fish, potentials of aquaculture resource bases (e.g., land and water), availability of aquaculture inputs (e.g., seeds and feeds), and availability of financial and human resources to support aquaculture development.

3.2 Aquaculture Development Objectives and Priorities

The survey responses indicated that the aquaculture development objectives of the participating countries basically center around increased productivity and aquaculture production; employment generation and fish for domestic consumption. As shown in Table 6, most countries (12 of 14) indicated increased productivity and aquaculture production as their first priority, and two countries indicated supply of quality fish food for domestic needs as the first priority.

Table 6. Aquaculture development objectives

Aquaculture Development Objectives	Countries	% of countries
Increased productivity and aquaculture production (first priority of 9 countries)	BGD; CPR; DRK; HOK; IND; IRA; NEP; PAK; PHI; SRL; THA; VIE	86
Employment generation (first priority of 1 country)	BGD; INS; IRA; NEP; PAK; SRL; VIE	50
Supply of quality fish food for domestic needs (first priority of 2 countries)	BGD; INS; IRA; SRL; THA; VIE	44
Increased income for fishfarmers	NEP; PAK; SRL; THA	29
Improved export earning	BGD; PAK; SRL; THA	29
Industrialization and modernization of aquaculture (first priority of 1 country)	DRK; MAL; VIE	21
Minimization of ecological damage & impacts	CPR; MAL	14
Improve quality of life for small scale fishfarmers (first priority of 1 country)	INS; PHI	14
Expansion or identification of new culture areas/sites	HOK	7

While physical space, i.e., land and water, available for aquaculture development is limited, the countries reported that the potentials for increased aquaculture production and increased productivity are high. Basic strategies to be used in achieving aquaculture development objectives include optimum and intensive use of water bodies, expansion of culture in underutilized areas, refinement and innovations in culture systems and technologies through research, improvement of management techniques, upgrading of farmer capabilities, and implementation of policies and regulations that facilitate availability of quality inputs, private sector participation and efficiency in resource use.

The priority actions in the national aquaculture development plan are summarized in Table 7. It is not surprising to see that the national aquaculture development plans give priority to those activities concerned with reliable supply of quality inputs, e.g., seed and feed; sustainable use of resource bases, e.g., water and land; and environmental and health management.

However, it is interesting to observe that the aquaculture development plans of many countries pay considerable attention to technology transfer and farmers' skill development; development of infrastructure and supporting facilities, socio-economic assessment and interventions; and improvement and enforcement of aquaculture legislation, regulations and policies.

Table 7. Aquaculture development priorities

Activities	Countries	Total countries No	%
Breeding & seed production	CPR, DRK, HOK, IND, INS, IRA, MAL, NEP, PHI, SRL, THA, VIE	12	86
Infrastructure & facility development	BGD, DRK, IND, INS, IRA, MAL, PAK, PHI, SRL, THA	10	71
Technology transfer, extension & skill training	BGD, CPR, IND, INS, IRA, NEP, PAK, PHI, THA, VIE	10	71
Environmental management & biodiversity	CPR, DRK, HOK IND, INS, IRA, MAL, PHI, THA, VIE	10	71
Culture sites, Identification & expansion	CPR, HOK, IND, INS, MAL, NEP, PAK, SRL, THA	9	64
Socio-economic assessment & interventions	BGD, CPR, IND, INS, NEP, PAK, PHI, SRL, THA	9	64
Fish nutrition & feed development	CPR, HOK, IND, INS, MAL, PHI, SRL, VIE	8	57
Health management	CPR, DRK, HOK, IND, PHI, SRL, THA, VIE	8	57
Inland waters, intensive use, & stock enhancement	CPR, DRK, IRA, MAL, NEP, PAK, PHI, SRL	8	57
Legislation, regulations & policies, improvement & enforcement	CPR, HOK, INS, MAL, PHI, SRL, THA, VIE	8	57
Species diversification	CPR, DRK, HOK, INS, MAL, SRL, THA	7	50
Genetic improvement	CPR, DRK, IND, MAL, PHI, THA	6	43
Marketing & market development	BGD, CPR, PAK, THA, VIE	5	36
Postharvest handling & product development	CPR, IND, MAL, PAK, VIE	5	36
Integrated fish farming	CPR, IND, MAL, NEP, SRL	5	36
Intensification of culture systems	CPR, IND, INS, PHI, VIE	5	36
Population dynamics & stock assessment	PHI	1	7
Culture and technology development*	All countries	14	100
• Integrated fishfarming	CPR, IND, MAL, NEP, SRL	5	36
• Intensification of culture systems	CPR, IND, INS, PHI, VIE	5	36

* Although target species vary, all countries indicated that culture and increased production are one of the main priorities in national aquaculture development plans. Most of the countries also indicated specific aspects of culture systems and technologies, e.g., breeding & seed production, disease control, etc., that were given priority considerations in the national plan. All activities that were expressed in the survey and national reports were recorded in summarizing the survey returns. See Annex 4 for details, including target species.

Although there exist some variation in key cultured species, all countries are concerned with expansion and promotion of culture of high value species such as prawn & shrimp, grouper, seabass, snapper, oyster, crab, etc. for the export market. For domestic and rural

consumption, carp, milkfish, catfish, tilapia and other low value or inland species are promoted for culture.

It was reported that the main beneficiaries of development projects/programmes are fishfarmers, hatchery operators and aquaculturists. Some actions are directed to improve capacities of the government agencies so that they can better assist their clients, e.g., fishfarming communities, private entrepreneurs, etc.

3.3 Constraints and Issues in Aquaculture Development

The countries have made significant progress in aquaculture development, particularly increased production, through improved technology, intensification of culture system and expansion of production areas. However, the agencies that are responsible for national aquaculture development reported a number of constraints and issues that impede formulation and implementation of national aquaculture development plans and programmes (Table 8).

It is important to note that some of the most common constraints in aquaculture development of the countries are of an institutional nature and relate to development planning and management and to utilization of technology and information. Weak institutional linkages and coordination in sector planing and management, combined with overlapping jurisdiction, lack of aquaculture legislation, regulations and policies, and inefficient exchange and use of information, suggest that aquaculture development is very much affected by non-technical impediments.

Issues relating to human resources were mentioned by 93% of the countries as a major constraint, with lack of skilled technical personnel as a key problem in 71 % of the countries. However, in spite of the most common constraints noted above, i.e., issues relating to management, legislation, effective utilization of technology and information, no country indicated lack of expertise in management, planning, development and legislation as a hindrance. Similarly, no mention was made of the lack of expertise in information management or development communication, or absence of policy framework required for balanced and effective human resource development.

As to technical and physical constraints, 71 % of the countries reported pollution and environmental factors as key environmental constraints. Reliable supply of quality seed and feed, and management and control of fish health and environment were reported as key technical constraints by 50% and 58% of the countries, respectively. It is interesting to note that 36% of the countries mentioned that lack of infrastructures and supporting facilities as constraints, but only one country reported inadequate aquaculture enclosures and engineering as constraints. Inadequate postharvest handling and product development was mentioned by only 29% of the countries.

Meanwhile, the countries reported various socio-economic factors as constraints in aquaculture development, particularly inadequate marketing (43%) and issues relating to loans and credits to fishfarmers (43%). Three countries (21%) reported low price or demand for inland fish as a key constraint.

Table 8. Issues and constraints in aquaculture development

Issues and Constraints	Countries
Institutional & Socio-economic Aspects	
• Ineffective technology transfer & lack of technology packages	BGD, CPR, HOK, IND, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE (93%)
• Weak institutional linkages and coordination, including public & private sectors	BGD, IND, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE (79%)
• Lack of skilled technical personnel	CPR, HOK, INS, IRA, NEP, PAK, PHI, SRL, THA, VIE (71%)
• Lack of information delivery methods & mechanisms; information exchange & dissemination	BGD, DRK, HOK, INS, IRA, MAL, NEP, PHI, VIE (64%)
• Weak enforcement of regulations & timely intervention	CPR,IND, NEP, PHI, SRL, THA, VIE (50%)
• Overlapping jurisdictions; lack of legal guidelines to avoid intersectoral conflicts	BGD, HOK, IND, PHI, SRL, THA, VIE (50%)
• Lack of regulations on sitting, zoning, water quality effluent management	IND, INS, MAL, NEP, PHI, SRL, VIE (50%)
• Inadequate marketing & involvement of middlemen	IND, MAL, NEP, PAK, THA, VIE (43%)
• Lack of loan support and credit assistance	BGD, IND, MAL, NEP, PHI, VIE (43%)
• Lack of skilled extension personnel	IND, PAK, PHI, SRL
• Inefficient administration; lack of representation at decision making level	INS, IRA, NEP, SRL
• Low support for aquaculture	CPR, HOK, NEP
• Insufficient or uncoordinated training & HRD	IND, MAL, VIE
• Low price of inland fish & demand	HOK, PAK, SRL
• Inefficient/Ineffective plans or policies	INS, NEP
• Lack of incentives for private sector	PAK
• Security at culture sites & risk, i.e., frequent failure	INS
• Difficulty in finding workers in aquaculture	THA
• Low priority given to welfare of fishermen	SRL
• Underutilization of skilled manpower	BGD
• Cumbersome recruitment of personnel	SRL
Technical & Environmental Aspects	
• Pollution and other environmental factors	CPR, HOK, IND, INS, MAL, NEP, PHI, SRL, THA, VIE (71%)
• Effluent & water treatment; farm management	HOK, IRA, MAL; NEP, PAK, PHI, SRL, THA (58%)
• Insufficient supply of quality seed	BGD, CPR, IND, INS, MAL, PHI, SRL (50%)
• Lack of quality fish feeds & feed ingredients	BGD, IND, INS, MAL, PAK, PHI, SRL (50%)
• Fish health management & pest control	CPR, HOK, IND, INS, MAL, PHI, SRL (50%)
• Insufficient infrastructure, e.g., hatcheries, feed mills, storage & postharvest processing facilities, etc.	CPR, IND, NEP, PAK, SRL
• Weak postharvest handling & product development	IND, MAL, NEP, PAK
• Shortage of suitable culture sites	HOK, IND, SRL
• Lack of or inadequate culture technologies*	DRK, VIE
• Inadequate aquaculture enclosures & engineering, e.g., design & construction of farms, ponds, cages, pens, water circulation/recycling systems, etc.	VIE
• Lack of survey data	IND
• Lack of EIA	VIE

Note: * Specific culture systems or technologies were not indicated.

4. AQUACULTURE DEVELOPMENT RESEARCH

4.1 Aquaculture Development Research Planning

The research sector supports national aquaculture development with improved and applicable aquaculture policies, technologies, and management methods and tools for environmentally sound and socially responsible aquaculture.

All countries have a national agency, under the ministry of agriculture, fisheries or science & technology, that plans and coordinates the national aquaculture research agenda and programmes. As the summary Table 9 showes, the responsible agencies working closely with the agencies in charge of overall development of national aquaculture, determine research priorities and formulate national aquaculture research programmes.

Table 9. Processes followed in setting national aquaculture research priorities

Countries	Processes followed	Participating groups
BGD	• Government initiative • Consultative	• **Bangladesh Agriculture Research Council (BARC)** - responsible for planning and coordination of national aquaculture research programmes • Ministry of Fisheries & Livestock & its Planning commission • Dept. of Fisheries; Fisheries Research Institute & NGOs for problem identification • Academic & research institutions
CPR	• no information	• no information
DRK	• Central planning	• **Korea Academy of Fisheries, Korea State Academy** - responsible for planning and coordination of nationai aquaculture research programmes • Fisheries research institutions
HOK	• Local initiative • Consultative	• **Agriculture & Fisheries Dept.** - responsible for planning and coordination of national aquaculture research programmes • Other related government agencies • Fishfarmers; Special interest groups, e.g., environmentalists • Research & academic institutions
IND	• Consultative	• **Indian Council for Agricultural Research (ICAR)** - responsible for formulation of research projects and programmes • Dept. of Agriculture & Cooperation; Planning Commission of the Ministry and its Working Groups • Research organizations • State fisheries departments
INS	• Consultative, using policy oriented path, analytical path, monitoring and evaluation	• **Central Research Institute for Fisheries (CRIFI), AARD** - one of agencies responsible for planning and coordination of national aquaculture research. Others are Agency for Technology Assessment and Application and Indonesian Science Institute • Dept. of Agriculture & its Directorate Generals, including DGF • Review Teams & scientific committees of the Ministry, BAPPENA, BPTP, LIPI • Extension agencies; Regional Fisheries Services • Private sector & Fishfarmers
IRA	• Consultative	• **Iranian Fisheries Research and Training Organization (IFRTO)** - responsible for planning and implementation of national aquaculture research programmes • Experts & research community • Government agencies and Research councils

Countries	Processes followed	Participating groups
MAL	• Consultative • Approval by Agro-Industry Panel of MOSTE	• **Fisheries Research Institute, Dept. of Fisheries Malaysia** - responsible for planning and coordination of national aquaculture research programmes • Government agencies; Agro-Industry Panel of MOSTE • Research community • Industry & private sector
NEP	• Central planning	• **Fisheries Research Div., Nepal Agricultural Research Council** - responsible for planning and coordination of national aquaculture research programmes • Government agencies, e.g., Dept. of Agriculture, Fisheries Development Division, Fisheries Research Centres • Aquaculture extension agencies
PAK	• Central government initiative • Consultative - between central and provincial governments	• **Livestock Div., Ministry of Food, Agriculture and Livestock** - responsible for planning and coordination of national aquaculture research programmes • Central research organizations, i.e., NARC & PARC • Research units of provincial Dept. of Fisheries • Research & academic institutions • Fishfarming communities • Research funding agencies; Economic Council
PHI	• Consultative & participatory	• **Philippine Council for Aquatic and Marine Sciences Research and Development (PCAMRD)** - responsible for planning and coordination of national aquaculture research programmes • Government fisheries agencies at all levels, importantly BAR and BFAR • Local governments • NGOs and People's organizations; Private sector • Research & academic institutions
SRL	• Central initiative by NARA • Consultative	• **National Aquatic Resources Research and Development Agency (NARA)** - responsible for planning and coordination of national aquaculture research programmes • Government research agencies • Academic and research institutions • Shrimp Farmers' Associations
THA	• Central planning	• **Office of Fisheries Technical Advisor, Dept. of Fisheries, Min. of Agriculture and Cooperatives** - responsible for planning and coordination of national aquaculture research programmes • Other institutions & divisions concerned with aquaculture
VIE	• Central government initiative • Consultative	• **Department of Science & Technology, Ministry of Fisheries** - responsible for planning and coordination of national aquaculture research programmes • Fishfarmers • Academic and Research institutions • Provincial experiment Centres • Extension agencies • Private sector, e.g., associations and service companies

Research priority setting is reported to follow consultative and/or participatory processes, using both top-down and bottom-up approaches that are similar to the processes used in formulating national aquaculture development plans. The survey indicated that research organizations and the research community as a whole have close linkages with the research planning agencies and play an important role in formulating aquaculture development

research programmes and plans. The survey also indicated that the agencies that administer national research grants, e.g., LIPI in Indonesia, Agro-industrial Panel in Malaysia and PCAMRD in Philippines, have influence over aquaculture research directions as they determine the research projects that will receive research grants.

Seven of 14 countries indicated that fishfarmers, fishfarming communities, industry and private sector also participate in the research priority setting exercise. However, as with the process followed in aquaculture development plans, the survey responses did not show the extent to which the agencies and research organizations in the related sectors such as industry and environment, participate or collaborate in setting priorities.

Of the many factors considered in setting aquaculture research priorities, the most common criteria used are national development plans and priorities; field problems & fishfarmers' needs; availability of funds, land, water, expertise and manpower; and local and provincial development needs. Few countries reported giving attention to such criteria as potential benefits to the poor; contribution to national food security (e.g., availability of fish for domestic consumption; contribution to management of fisheries and aquatic resources); or potential impacts on the development of the sector. In spite of the fact that one of the aquaculture development objectives is generation of employment and income generating opportunities (see Table 6), only three countries mentioned this as one of the key criteria used in setting research priorities in aquaculture.

Table 10. Criteria used in setting development research priorities

Criteria used	Countries
National development plans and priorities	BGD; IND; INS; IRA; MAL; PHI; SRL; THA; VIE
Field problems and fishfarmers' needs	BGD; HOK; IND; NEP; PAK; SRL; VIE
Availability of funds, land, water, expertise and manpower	BGD; HOK; IND; IRA; MAL; SRL
Local and provincial development needs	IND; IRA; PAK; PHI; VIE
Needs of government agencies	BGD; IRA; SRL
Needs of industry & private sector	MAL; PHI; SRL
Potential contribution to income and employment generation	IND; INS; IRA
Potential contribution to sector development	HOK; INS
Potential contribution to national economy	IRA; PAK
Technological innovation	INS; PAK
Potential contribution to increased production	NEP; PAK
Potential contribution to export earnings	PHI
Potential contribution to production of fish for domestic consumption	PHI
Interests and criteria of funding agencies	PAK
Recommendations of national workshops	BGD
Potential contribution to mangement of fisheries resources and stocks	PAK
Potential benefits to poor	INS

Note: No information was provided by China and the Democratic People's Republic of Korea.

4.2 Aquaculture Research Priorities

The survey responses indicate that national aquaculture research priorities correspond to the priorities of national aquaculture development plans (Table 11). That is, technology development for breeding, seed production, feed production, health and environmental

management, and genetic improvement dominates aquaculture development research priorities.

Table 11. Aquaculture development research priorities

Activities	Aquaculture development research priorities	Total countries No	%
Breeding & seed production	BGD, CPR, DRK, IND, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE	13	93
Environmental management & biodiversity	BGD, CPR, DRK, HOK, IND, INS, MAL, NEP, PHI, SRL, THA, VIE	12	86
Health management	BGD, CPR, HOK, IND, INS, IRA, MAL, NEP, PHI, SRL, THA, VIE	12	86
Fish nutrition & feed development	BGD, CPR, DRK, HOK, IND, INS, IRA, MAL, NEP, PHI, THA	11	78
Genetic improvement	BGD, CPR, DRK, IND, INS, IRA, NEP, PAK, PHI, THA, VIE	11	78
Inland waters, intensive use & stock enhancement	BGD, DRK, IND, INS, NEP, PAK, SRL	7	50
Population dynamics & stock assessment	BGD, DRK, PAK, PHI, SRL	5	36
Species diversification	DRK, HOK, MAL, VIE	4	28
Legislation, regulations & policies	DRK, PHI, SRL	3	21
Postharvest handling & product development	BGD, CPR, VIE	3	21
Socio-economic assessment & interventions	BGD, IND, NEP	3	21
Aquaculture engineering, e.g., design of pond, cage, pens, water recycling systems, etc.	HOK, IND, MAL	3	21
Culture sites, identification & expansion	HOK, INS	2	14
Culture and technology development*	All countries	14	100
• Integrated fish farming	BGD, IND, PHI, SRL	4	28
• Intensification of culture systems	BGD, DRK, IND, PAK	4	28

Note: * - See Annex 5 for detailed summary.

All countries reported to give a priority to the refinement and development of culture systems and technologies. Research on semi-intensification or intensification, and integrated farming systems as priority were specifically mentioned by several countries. In spite of global concerns for sustainable aquaculture and food security, development of technologies for low-input and low-cost aquaculture systems, except integrated fishfarming with agriculture, were not specifically highlighted.

It is important to note that (a) only a few countries give priorities to research on the identification of potential culture areas; study on aquaculture legislation, regulation and policies; research on postharvest handling and product development; and research on socio-economic aspects of aquaculture, and that (b) the countries give no priority to research on markets and marketing; study on strategies, methods and mechanisms for improved technology transfer and extension, and study on requirements and strategies for human resource development and development of infrastructure and supporting facilities.

4.3 Research Areas Recommended by Recent Regional and International Meetings and Studies

Recently, a number of regional and international studies and meetings have considered ways to respond to various constraints in aquaculture development, including adverse effects resulting from the rapid growth and unplanned development and expansion of aquaculture. Of the 19 regional and international studies and meetings reviewed, 12 addressed specific issues such as environment, women, shrimp, diseases, chemicals, etc. and 7 examined the general aspect of aquaculture. The studies and meetings recognized that research is required to better understand causes of adverse effects, and to find measures to deal with the challenges facing the aquaculture sector, and recommended priority research areas.

Table 12. Aquaculture research areas recommended by international and regional fora/studies

Research themes	Research areas recommended by regional & international fora
Environmental management	**Shrimp-96:** environmental impacts of shrimp culture; management of shrimp pond sediments; assessment & management of water quality & quantity; effects of acid sulphate soils on shrimp pond environment; rehabilitation of abandoned shrimp ponds & mangrove **Commercial/shrimp-96:** environmental degradation in specific ecological, social and political contexts; social and environmental implications of commercial shrimp farm expansion **Legal-96:** pollutant loading; carrying capacity; rehabilitation & re-use of abandoned operations **BOBP-96:** methodology for EIA; protocols & guidelines for siting and cluster density; standards for effluents; rehabilitation & reuse of abandoned operations **Kyoto-95:** impact on environment and biodiversity; health of cultured stock **Sustainability-95:** methodologies to quantify environmental impacts; development of national water management policies and systems; formulation of water and effluent quality standards; development of aquaculture system that make efficient use of water; re-use of water; addition of market value to sediments; best management practices for sediment; conservation and rehabilitation strategies **Environment-94:** standard methods for environmental monitoring of aquaculture; methodologies for assessing environmental impact; assessment of magnitude and impact of mangrove destruction; measures for rehabilitation of mangroves; assessment of environmental impacts of drugs and chemicals; assessment of impacts of exotic species on indigenous aquatic biodiversity; integrated use of water; standards for effluent management & water quality; reduction of sediment loads; sediment utilization; rehabilitation of mangrove & abandoned sites **IPFC/experts-94:** relationship between intensification of culture systems and environmental impacts **ASEAN-94:** ecological impacts of shrimp culture **ADSEA-94:** rules & regulations for aquaculture not to exceed the carrying capacity of the environment; carrying capacity of sensitive ecosystems; use of open sea **Experts/Rome-94:** ecosystem management; performance indicators for sustainable aquaculture; minimization of waste & environmental damage **NACA/TAC-92:** management of effluent

Research themes	Research areas recommended by regional and international fora
Culture systems & technologies	**Shrimp-96:** shrimp pond management **Legal-96**: codes of practice **Sustainability-95:** culture systems **Seaweed-95:** polyculture & integrated seafarming; **ASEAN-94:** integrated fishfarming **IPFC/experts-94:** farming systems approaches; aquaculture techniques appropriate for local physical and socio-economic context of small-scale farmers **Experts/Rome-94:** analyze the scope of spatially dispersed inland culture fisheries integrated into farming systems **NACA/TAC-92:** marine finfish culture
Breeding & seed production	**BOBP-96:** seed supply & hatchery development **Sustainability-95:** guidelines for healthy seed and broodstock quality **ASEAN-94:** hatchery & nursery technologies; seed production **Environment-94:** guidelines for health & quality of seeds and broodstock; improved hatchery operation for carp; domesticated shrimp seed stocks
Health management	**Shrimp-96:** shrimp disease prevention and management **Chemicals-96:** efficacy of chemicals **BOBP-96:** prevention & control of diseases **Sustainability-95:** rapid disease diagnostic procedures; guidelines for use of probiotic materials **Environment-94:** health & disease management **Disease-93:** improvement in diagnostic techniques, control and management, including training on dissemination and transfer of technology; assessment of disease status, both pathological and economic terms; environmental impacts
Genetic improvement	**Shrimp-96:** improved domesticated shrimp broodstock; sustainable domesticated shrimp broodstock supply **Sustainability-95:** genetic improvement of carp; development of domesticated shrimp seed stock; disease-tolerant varieties **Seaweed-95:** taxonomy of Gracilaria **IPFC/experts-94:** improvement of cultured stocks **ASEAN-94:** genetic finger-printing; genetic manipulation & hybrids **Environment-94:** development of disease-free broodstock and production of healthy seed **NACA/TAC-92:** conservation & promotion of indigenous species
Feed & nutrition	**Shrimp-96:** development of quality low pollution feeds; feeding strategies **BOBP-96:** feed development & improvement **Sustainability-95:** standards for environmentally sound formulation and utilization of feeds; well-formulated farm-made feeds **Environment-94:** nutrient requirements of important species; standards for feeds **ASEAN-94:** feed development & improvement **NACA/TAC-92:** live feed for marine finfish & crustacean; low-cost, balanced feed formulation
Intensive use of inland waters & Stock enhancement	**Kyoto-95:** environmentally sound stocking **Sustainability-95:** guidelines for inland water utilization **ASEAN-94:** development of inland fisheries **Experts/Rome-94:** assessment of inland water resources **NACA/TAC-92:** management of culture-based fisheries in inland waters
Postharvest handling; Product development; Marketing	**Seaweed-95:** improved processing of Gracilaria **Kyoto-95:** minimize postharvet losses **ASEAN-94:** technologies for postharvest processing & quality control **Experts/Rome-94:** improvement of product quality and price acceptable to consumer **Postharvest-94:** all aspects of processing and product development, including marketing and quality assurance

Research themes	Research areas recommended by regional & international fora
Social and Economic aspects	**Shrimp-96:** social conflicts over alternative land use options and coastal land use planning for shrimp farming; social benefit & cost study on all aspects of shrimp farming, industry and farming systems; factors affecting success and failures of shrimp farming **Commercial/shrimp-96:** social and environmental implications of commercial shrimp farm expansion **Women-96:** gender issues **BOBP-96**: methodology for social impact assessment **Women-95:** gender issues, e.g., impacts of aquaculture policies, technology, systems, practices, projects on women; methodologies to assess contribution of women to the sector **ASEAN-94:** socio-economic impacts of shrimp culture **ADSEA-94**: marcoeconomics and social feasibility of intensive monoculture systems **Experts/Rome-94:** aquaculture trade; issues relating to products destined for consumption by poor; market & marketing; guidelines on aquaculture research priorities; research support & utilization of research outputs; case study on aquaculture successes and failures; research on human subsystem **Socioeconomics-94:** all social & economic aspects of aquaculture
Legislation, regulations, policies, & management aspects	**Shrimp-96:** plans & strategies for integrated coastal zone management; international trade agreements, government polices and management instruments relevant to development and mangement of shrimp industry; cost effective training & information transfer **Commercial/shrimp-96:** political economy of shrimp farming; institutional linkages, constraints and opportunities; effects of public policies and economic constraints & alternatives **Legal-96:** aquaculture legislation **Kyoto-95:** sustainable contribution of fisheries to food security **Sustainability-95:** aquaculture legislation **IPFC/experts-94:** guidelines for aquaculture legislation; guidelines for improved cooperation, coordination and linkages with other sectors **Experts/Rome-94:** regulatory devices & alternative techniques as incentives; policy concerning role of fish in food security; options for reducing imbalance between demand and supply of fish and fish products; technology transfer **Socioeconomics-94:** policy, legislation and regulatory issues for sustainable aquaculture

Note: See references for sources. The number in parenthesis corresponds to reference number. Shrimp-96 (1); Commercial/shrimp-96 (2); Chemical-96 (3); Legal-96 (4); Women-96 (5); BOBP-96 (6); Kyoto-95 (7); Sustainability-95 (8); Environment-94 (9); Women-95 (10); Seaweed-95 (11); IPFC/Experts-94 (12); ASEAN-94 (13); ADSEA-94 (14); Experts/Rome-94 (15); Socioeconomics-94 (16); Postharvest-94 (17); Disease-93 (18); NACA/TAC-92 (19)

The international and regional studies and meetings gave considerable attention to research on socio-economic aspects, policy, and legal and regulatory issues that were not emphasized in the responses to the current study (Table 12). Furthermore, the research areas recommended by the regional and international studies and meetings appear to be more closely related to the issues and constraints in aquaculture development noted earlier (see Table 8). There is a need to examine the processes and criteria used in identifying aquaculture development research needs and priorities at all levels, particularly in view of the fact that the recommendations of the international and regional studies and meetings were formulated and adopted by the representatives of the participating countries.

4.4 Aquaculture Research Capacities

The countries have a significant number of aquaculture research organizations (Table 13). All main aquaculture research organizations are affiliated either with government agencies (mainly with the ministry of agriculture, fisheries, education, or science and technology) or with academic institutions. No country listed private sector research organizations.

The programmes and competence of the main research organizations cover a broad spectrum of disciplines, emphasizing fish breeding and seed production, genetics, fish health, feed and nutrition, culture technologies and systems, conservation and enhancement of aquaculture environment, effluents, and soil and water management.

Significantly, there is no mention of competence or programmes in aquaculture management, planning, economics and marketing, social sciences, legal and policy studies, and postharvest handling and product development.

Table 13. Main aquaculture research organizations and their programmes

Countries	Main research organizations	Areas of competence or main programmes
BGD	Fisheries Research Institute, Ministry of Fisheries & Livestock and six research stations; Bangladesh Agriculture University	All aspects of aquaculture, emphasizing culture technologies & systems, floodplain & integrated fishfarming, breeding & seed production, genetics, health & environmental management, feed &nutrition, product development, quality control, fisheries economics, soil & water management
CPR	Ten research institutes under the Chinese Academy of Fisheries Science (CAFS), Ministry of Agriculture; Three Institutes under Chinese Academy of Science; Five universities & colleges; One institute under a provincial ministry	All aspects of aquaculture There are 184 fishery science and aquaculture research institutions with approximately 6,000 professional research personnel.
DRK	Four aquaculture research institutions under Korea State Academy	All aspects of sea animal and seaweed production and fish farming
HOK	Agriculture and Fisheries Department and its three stations; Universities are also active in marine biology, feed and ecological studies	All aspects of aquaculture
IND	Seven research institutes under Min. of Agriculture; Nine state organizations either under the state Min. of Agriculture or Min. of Education	All aspects of aquaculture
INS	Eight institutes and centres under the Min. of Agriculture; Six universities under the Min. of Education	All aspects of aquaculture; emphasizing key commodities determined by AARD
IRA	Sixteen research organizations, centres and stations	All aspects of aquaculture, emphasizing sturgeon, marine finfish, freshwater fishes, coldwater fishes, shrimp, oyster, seaweed
MAL	Two institutes under the Min. of Agriculture; Four universities under the Min. of Education; Two organizations under the state Min. of Agriculture	All aspects of aquaculture, emphasizing culture technologies and systems, breeding and seed production, diseases and health, nutrition, genetics

Countries	Main Research Organizations	Areas of competence or main programmes
NEP	Five centres under the Nepal Agriculture Research council; One university under the Min. of Education	Aquaculture in coldwater, riverine, lake, reservoir and warmwater pond; carp culture, fish ecology and taxonomy, environmental impact assessment
PAK	Three institutes under the Min. of Food and Agriculture; Five universities under the Min. of Education; Pakistan Science Foundation under the Min. S&T; Research and Training Centre under the Directorate of Fisheries of Punjab	Problem-oriented research in culture technologies and system, breeding, genetic improvement, feeds; biological and management aspects; basic and taxonomic research; limnology; postharvest handling
PHI	Two bureaus, and four centres and stations under the Dept. of Agriculture; One main research council under the Dept. S&T Two autonomous universities; One university under the Dept. of Education; ICLARM; SEAFDEC	All aspects of aquaculture, focusing on shrimp, crab, seaweed, catfish, carp, grouper, seabass, siganid, sea urchin, tridacna, pholas, placuna, abalone, milkfish, tilapia,
SRL	One main research agency under the Min. of Fisheries and Aquatic Resources; Six universities under the Min. of Higher Education	Culture of shrimp, ornamental fish, bivalve, artemia; wetland management; utilization of problem soils for shrimp culture; inland fisheries management; fish disease; integrated fishfarming; reservoir fisheries; fish breeding
THA	Nine institutes and organizations under the Dept. of Fisheries; Six universities; AIT	All aspects of aquaculture
VIE	Four institutes under the Min. of Fisheries; Two universities	Freshwater and coastal aquaculture, emphasizing fish diseases, seed production, fish processing, seafarming, culture of shrimp, prawn, seaweed, mollusc and marine fish

The survey also revealed that the countries have a considerable number of research personnel (Table 14). The majority (75%) specialize in biological sciences, and only a few specialize in such areas as physical and engineering sciences (6%), social sciences (3%), economics (2%), policies and legal studies (0.3%). It is understood that specialists affiliated with non-aquaculture organizations and agencies could effectively participate in aquaculture research through cooperative and collaborative programmes and arrangement. However, the survey responses did not indicate the nature and extent of participation of research personnel from non-aquaculture or non-fisheries organizations. There was no clear indication that multidisciplinary or intersectoral approaches are encouraged in formulating aquaculture development plans and research programmes.

Table 14. Reported number of research personnel by country

	No. of Org.#	Biological sciences	Physical & eng'g sci.	Social sciences	Econo mics	Legal studies	Others	Total
BGD	1	124	17	-	1	-	142[3]	284
CPR	3	226	72	-	-	-	-	298
DRK	n	n						n
HOK	3	35	-	-	-	-	-	35
IND	6	721	20	1	10	-	12[3]	764
INS[1]	7	-	-	-	-	-	-	204[3]

	No. of Org.#	Biological sciences	Physical & eng'g sci.	Social sciences	Econo mics	Legal studies	Others	Total
IRA	n	n						n
MAL	1	14	2	-	-	-	18[4]	34
NEP[1]	6	-	-	-	-	-	-	24[3]
PAK	4	81	4	4	2	3	-	94
PHI	4	72	2	4	4	1	9[3]	92
SRL	5	98	54	16	13	-	205[5]	386
THA	5	754	-	55	13	3	-	825
VEI	6	135	20	5	1	2	24[3]	187
Total	51	2260	191	85	54	9	410	3227
% of Total[2]	-	75.3	6.3	2.8	1.8	0.3	13.6	-

- Number of research organizations that provided data.
1 - Specialization of personnel was not indicated.
2 - Percentage was calculated by excluding Indonesia and Nepal
3 - specialization was not specified.
4 - 1-environmetal science; 2-chemistry/biochemistry; 7-fisheries; 8-others
5 - Agricultural specialists, e.g., biology, soil, etc.
n - no information

In addition to the national aquaculture research organizations, several regional and international organizations located in Asia support research activities to promote aquaculture development in the region. For example, the Asian Institute of Technology (AIT) and Aquaculture Department of Southeast Asian Fisheries Development Centre (SEAFDEC/AQD) are known for their expertise in a broad range of aquaculture, from breeding, genetics, environmental and health mangement to postharvest handling; and the Aquatic Animal Health Research Institute (AAHRI), Department of Fisheries, Thailand for its expertise in all aspects of fish health management. They have been making an important contribution to regional human resource development and aquaculture research. ICLARM, FAO/RAP, INFOFISH, MRC, NACA and SEAFDEC/AQD have been supporting and promoting aquaculture development by initiating and implementing various regional cooperative actions in development, research, institutional capacity building and human resource development, as well as facilitating information exchange and dissemination.

Professional organizations and research networks such as the Asian Fisheries Society (AFS), Network of Tropical Aquaculture Scientists (NTAS), and Aquaculture Genetics Network of Asia (AGNA), facilitate regional cooperation in aquaculture research and information exchange. The programmes of these regional and international organizations support the national efforts and complement national research capacities.

4.5 On-going Aquaculture Development and Research Efforts

The survey suggested that considerable research efforts are on-going in the countries; 330 aquaculture development and research projects were reported by twelve countries (note: no specific information on on-going projects was provided by Korea DPR and Iran).

Review of the main thrusts of the projects showed that technology development dominates existing research efforts. Approximately 22 % (71) of the on-going projects are concerned with improvement of culture systems and technologies; 12 % (41) with health management; 12 % (40) with breeding and seed production; 12 % (38) with genetic improvement; 10 %

(32) with species diversification; 9 % (32) with environmental mangement; and 9 % (28) with fish nutrition and feed development (Table 15).

While overall, there are more studies geared to improving culture systems and technologies than to other areas, China, Indonesia and the Philippines have more projects on health management. Together, health and environmental management comprise about 20% of the reported projects. Two of the main inputs to aquaculture, i.e., seeds and feeds, are the subject of 68 (20%) projects.

Research on policy, legislation, socio-economics, and postharvest were least mentioned. However, a fair amount of effort is being made in extension and training; i.e., about 5 % of the reported projects.

In terms of target beneficiaries, it was reported that approximately 76 % of the projects were for fisharmers and fishfarming communities; about 11% for extension or government technical officers; 5% for planners or managers; 4 % for industries; and 3 % for rural or coastal communities.

To obtain an indication of the thrusts of aquaculture projects funded by donors, aquaculture projects listed in the FIPIS (Fisheries Projects Information System) database that is maintained by FAO were examined (Table 16). The summary presented below seems to indicate that (a) donors support mainly activities such as research, aquaculture production, institutional support and training/extension and (b) there is a general trend for reduced donor support for aquaculture, particularly for research activity in Asia. This report does not examine the reasons for the reduced number of donor-supported projects.

Examination of 58 aquaculture research projects supported since 1990 revealed that approximately 28% of the projects were concerned with fish health; 12% with culture systems and technologies; 12% with fish nutrition and feed development; 12% with environmental management; 10 % with research infrastructure & institution building; 10% with genetics; and 9% with breeding and rearing. In common with the projects reported by the countries, few donor-funded projects were concerned with studies and investigation of socio-economic aspects (1 project), institutional arrangements, utilization of research outputs (2 projects), and legal or policy issues relating to aquaculture development and management (1 project).

The aquaculture research organizations that responded to this survey indicated that the main users of their research outputs are extension specialists, fishfarmers and fishfarming communities, followed by administrators and managers in fisheries/aquaculture agencies, industries, research community and policy planners. Booklets, demonstrations and training are the frequently used media for disseminating research findings to extension and fishfarming communities, while reports, seminars and workshops are used to communicate with administrators and policy planners. Journals, books, conference proceedings and reports are the media used for scientific community. Occasionally, mass media such as newspapers, radio and television are used to disseminate research findings of importance to the public.

Table 15. Main thrust of the on-going aquaculture research projects

Aquaculture Areas	BDG	CPR	DRK	HOK	IND	INS	IRA	MAL	NEP	PAK	PHI	SRL	THA	VIE	Total	
															No.	%
Culture systems and technologies	2	3		4	21	8		7	5	3	2	1	4	11	71	21.5
Health management	2	5		1	8	10		2	1	2	6	2		2	41	12.4
Breeding and seeds production	1	1		2	9	10		4	1	1		2	1	8	40	12.1
Genetic improvement	1	7		7	6	5		3	1	1	2		2	3	38	11.5
Species diversification		2		1	4	11		2	1			4	6	1	32	9.7
Environmental management		1		9	4	9						3		4	30	9.1
Fish nutrition and feeds	1	3		2	7	7		1			1		3	3	28	8.5
Extension, technology transfer & human resource development		1			7	2					2	1		3	16	4.8
Culture sites, identification and expansion		3		1	2			2			1		2		11	3.3
Inland waters, intensive use of, and stock enhancement	1				2	1				1		1		2	8	2.4
Socio-economic assessment & interventions					3						1			1	5	1.5
Legislation, regulation and policies		2											1	1	4	1.2
Postharvest handling and product development				1	1	1									3	0.9
Infrastructure and supporting facilities					2	1									3	0.9
Total	8	28		28	76	65		21	9	8	15	14	19	39	330	99.8

Table 16. Number of aquaculture projects in Asia funded by donors* reporting to FIPIS

	1990	1991	1992	1993	1994	1995	Total
Research	21	11	15	7	8	0	62
Aquaculture production	9	1	3	6	5	1	25
Institutional support	4	1	4	5	6	3	23
Training/extension	3	0	5	3	5	2	18
Environmental protection	0	0	1	3	2	0	6
Sector/feasibility study	2	0	0	1	0	1	4
Multicomponent (not costed)	1	0	1	2	0	0	4
Women in development	1	1	0	0	1	0	3
Survey/exploratory fishing	2	0	0	0	0	0	2
Processing & marketing	0	0	0	2	0	0	2
General line of credit	0	0	1	0	0	0	1
Fishery inputs	0	0	1	0	0	0	1
Total	43	14	31	29	27	7	151

*Note: Not all donors report their project information to FIPIS. What is shown here is an indication. Additionally, FIPIS information for 1995 is incomplete.

4.6 Issues and Constraints in Aquaculture Development Research

In spite of the existence of a large number of research organizations and personnel, and the established mechanisms and processes for formulating and implementing aquaculture research programmes, the survey indicated that the countries are faced with a variety of constraints and issues in planning and implementing aquaculture research programmes (Table 17). The most common of these relate to ineffective dissemination and exchange of information (93% of the countries), weak interagency linkages and inter-institutional coordination (86%), insufficient skilled personnel (86%), inadequate research facilities (86%), low level of research funding and support (71%), insufficient technology transfer (64%), lack of training opportunities (57%), and inadequate consultation and communication with users of research outputs (57%).

Table 17. Issues and constraints in aquaculture development research

Issues and Constraints	Countries
Administrative & Institutional Aspects	
• Lack of information delivery methods & mechanisms; information exchange & dissemination	BGD, CPR, DRK, IND, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE (93%)
• Weak institutional linkages and coordination, including public & private sectors	BGD, CPR, HOK, IND, INS, IRA, MAL, PAK, PHI, SRL, THA, VIE (86%)
• Lack of skilled technical personnel	BGD, DRK, HOK, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE (86%)
• Low/Limited funding for aquaculture development & research	BGD, CPR, HOK, IND, INS, PAK,PHI, SRL, THA, VIE (71%)
• Ineffective technology transfer & lack of technology packages	BGD, CPR, IND, INS, NEP, PAK, PHI, THA, VIE (64%)
• Insufficient or uncoordinated training & HRD	CPR, IND, INS, MAL, PAK, SRL, THA, VIE (57%)
• Low support for aquaculture (research)	BGD, INS, MAL, NEP, PAK, PHI, SRL, THA (57%)
• Inefficient administration; lack of presentation at decision-making level	BGD, IND, IRA, NEP, PHI, SRL (43%)
• Short-term research planning or frequent changes in management and program directions	INS, MAL, SRL

Issues and Constraints	Countries
• Lack of information for planning and management	INS, PHI, SRL
• Cumbersome recruitment policies/procedures	NEP, PAK, THA
• Inefficient/Ineffective research plans or policies	INS, NEP
• Lack of intellectual property right	MAL
• Lack of information on human resource requirement	IND
• Lack of skilled extension personnel	IND
Research Environment	
• Inadequate research facilities & equipment	BGD, CPR, DRK, IND, INS, IRA, NEP, PAK, PHI, SRL, THA, VIE (86%)
• Inadequate consultation & communication with clients, e.g., farmers, extension, private sector and policy planners	CPR, IND, INS, IRA, MAL, NEP, PAK, PHI (57%)
• Limited expertise and experience in research management & planning	BGD, INS, MAL, NEP, PAK, SRL (43%)
• Low motivation & incentives of research staff	HOK, IND, IRA, NEP, PHI, THA (43%)
• Lack of applied, field- or need-based research	HOK, IND, PAK, PHI, THA
• Heavy work load or lack of time for research	HOK, INS, MAL, PHI, THA
• Lack of farmer participation	INS, PHI, SRL
• Lack of international collaboration	CPR, IRA, NEP
• Cumbersome processes in procuring equipment & supplies	IND, IRA
• Lack of (basic) research	CPR, PHI
• Focus/Over emphasis on one species/topic (this thens to limit research on other areas or species)	IND, THA
• Lack of interdisciplinary research/social scientists	BGD, NEP
• Lack of understanding on impacts of aquaculture policies	INS
• Difficulties in balancing direct economic benefits and long-tern social impacts	CPR
• Interests of research institutions/researchers, e.g., interested in processes of research, not research results; tend to become an isolated centre of excellence	PHI

In spite of the reported existence of a significant number of research organizations and personnel in the countries, lack of skilled technical or research personnel emerged as the most common constraint in planning and managing aquaculture research. At the same time, the survey revealed such related issues as lack of incentives and motivation, uncoordinated training programmes, and lack of information on human resource requirements. This suggests that existing personnel may not be fully utilized or skills may not match needs. It does appear that the issues in human resources are more complex than merely lack of skilled technical personnel.

The aquaculture research sector seems adversely affected by inadequate research support such as poor research facilities and information services, which is closely linked to poor funding. Three countries reported lack of information for planning and management as key constraints.

Weak interagency linkages and lack of coordination in formulating and implementing aquaculture research programmes and projects was reported in several different ways, both under the general headings of the Administrative & Institutional Aspects and Research Environment; e.g., the lack of participation or consultation with planners, fishfarmers or private sector in planning and formulating research projects and programmes. It is interesting to note that several countries reported that lack of information sharing results in duplicated research efforts.

Significantly, a good number of countries reported the lack of or limited experience and expertise in planning and management of research programmes (43% of the countries) and inefficient administration as key constraints (43% of the countries). The survey responses suggest that the aquaculture research sector suffers from lack of continuity in planning and funding. Although mentioned by fewer countries, some of the more critical issues include

the frequent changes in research directions; lack of long-term research efforts; and lack of sound research plans and policies. The causes were not well explained, but annual budgeting process; i.e., annual approval of research projects and budgets, was reported as one of the reasons for lack of continuity.

Issues such as lack of field/problem-oriented research and farmer participation; over-emphasis on certain species/topics; lack of understanding on impacts of aquaculture policies; lack of interdisciplinary research; and difficulties in balancing direct (or short-term) economic benefits and long-term social impacts, were reported by few countries. However, these issues deserve more attention as they are closely related to the central functions of aquaculture development research. Furthermore, they may be causes of lack of support for aquaculture research and funding. There appears to be a need to strengthen national capabilities for aquaculture research management and planning, in order to enhance the contribution of research to the development and management of the aquaculture sector.

5. OBSERVATIONS

Aquaculture plays an important role in the livelihood of people and in the national economy of countries in Asia. It produces food fish which is an important component of the diet of the people; it provides income and employment opportunities for many coastal and rural people; and it helps earn foreign exchange. Thus, the objectives of national aquaculture development are to increase aquaculture production to meet demands for fish products for domestic consumption and export market, and to generate income and employment opportunities.

The basic strategies used to achieve objectives of national aquaculture development plans include application of improved culture technologies and systems; supply of quality inputs, i.e., seed and feed; development of culture facilities and infrastructure; management of fish health and the culture environment; and improvement of postharvest handling and product development. This indicates that the countries have place a priority on technological solutions as the means for promoting aquaculture development and deriving economic benefits.

The countries formulate national aquaculture development and research plans through consultative and/or participatory processes, involving government agencies at all levels, research organizations, fishfarming communities, private sector, professional and trade organizations, and other interest groups such as environmental NGOs and funding or donor agencies. However, the planning processes do not appear to facilitate or promote the participation of non-fisheries or non-aquaculture agencies and organizations.

National aquaculture research priorities are determined by using a variety of criteria. The most common are national development priorities; needs of fishfarming communities and the private sector; local and provincial development needs; and availability of funds, land and water resources, expertise and manpower.

The aquaculture sector has made significant progress in recent years, but a variety of issues and constraints threaten further development. The common constraints and issues are weak institutional linkages; lack of coordinated planning and programming; lack of skilled human resources; ineffective technology transfer and underutilization of information; pollution of aquatic environment; low support and funding for aquaculture research; lack of inputs and appropriate technologies for environmental and health management; and inadequate aquaculture legislation, regulations and policies.

Research is considered to be critical to support national aquaculture development since the management and removal of key constraints require application of scientific, technical and socio-economic knowledge and understanding. The national aquaculture research sector has given priority to developing and refining culture systems and technologies in support of increased production, particularly technologies for seed and feed production, genetic improvement and management of fish health, effluent and water.

To illustrate the current status of aquaculture development research, information presented in the previous sections is reiterated in Table 18, summarizing the survey responses, the priority research topics recommended by regional and international studies and meetings, and the research areas of the regional and international organizations by broad aquaculture activities or topics.

National aquaculture research priorities do not appear to give adequate attention to development issues and constraints related to socio-economics and planning and management aspects of the sector, despite the fact that weak interagency linkage, lack of coordinated planning, insufficient consultation with planners, extension specialists and fishfarmers, and lack of socio-economic assessment and interventions were cited as some of key constraints in planning and managing national aquaculture development and research.

Significantly, although one of the main aquaculture development objectives is concerned with the social and economic well-being, the stated research priorities and efforts give little attention to generating better understanding of social and economic impacts of aquaculture policies and socio-economic issues, and to finding alternative management strategies, instruments and interventions.

The research priorities recommended by recent regional and international meetings and studies seem to underscore the need to undertake research and generate new knowledge in various non-technical aspects of aquaculture, including policy, legislation, regulations, institutional and organizational arrangements, as well as culture systems and technologies. These recommended research areas correspond more consistently with the issues and constraints in aquaculture development reported by the countries in this survey. However, it is difficult to asses the extent to which the recommendations relating to non-technical areas were used or translated into the formulation of national aquaculture research programmes. According to the criteria reported by the countries, recommendations of regional and international meetings and studies were not mentoned as having been considered in the formulation of national aquaculture development and research programmes and priorities.

Although most countries consider their research facilities inadequate and in need of upgrading, it appears that the countries collectively have a considerable number of research organizations that are capable of undertaking research in various aspects of aquaculture, particularly in culture systems and technologies, breeding, genetic improvement, nutrition and feed formulation; and health and environmental management. The capacity to undertake research in socio-economic aspects, postharvest handling and product development was not clearly indicated.

In addition to the national aquaculture research organizations, the region has well established regional aquaculture research institutions and programmes, e.g., AAHRI, AIT and SEAFDEC/AQD, and several regional and international organizations that facilitate and promote aquaculture development and research. These regional organizations and programmes support and supplement the national efforts and make critical contributions to human resource and capacity development.

The survey indicated that the countries have a considerable number of research personnel. However, a good majority of research personnel in aquaculture specialize in biological sciences. The aquaculture research organizations reported having few or no specialists in non-biological and non-physical sciences or little access to them. This imbalance in specialization of research personnel may have been one of the main reasons for the concentration of research priorities and efforts on technological innovation based on biological sciences and lack of integrated research programmes/projects that respond to the socio-economic and environmental concerns confronting the sector. It is necessary for the aquaculture sector to give more attention to balanced human resource development and utilization.

Significant aquaculture development and research efforts are on-going in the countries, reflecting national aquaculture development and research priorities. Over 80 % of the 330 aquaculture projects reported are concerned with development and research on aquaculture technologies and systems; health and environmental management; production of seed and feed; genetic improvement and species diversification. Few on-going projects (less than 3%) are concerned with socio-economic and management aspects.

The thrusts of the aquaculture research projects funded by donor agencies show similar patterns as the national efforts, showing a good majority supporting technology oriented research.

The important contribution that research has made to the development of aquaculture, particularly the biological basis for cultivation of commercially important species, is well recognized. However, the constraints and issues in aquaculture development seem to indicate that the countries are not able to optimally utilize human and physical resources and fully benefit from available technologies because of weak management policies, institutional arrangement and coordination.

The survey responses indicated participation of private sector in formulating aquaculture development and research plans, but no significant role in conducting and supporting research. It is generally known that the private sector carries out significant research that results in commercial gain, e.g., development of drugs and feeds. Lack of information on private sector research capacity and research supported by private sector could be attributed to the proprietary nature of private sector research.

The private sector derives significant benefits from technological innovation in culture technology and systems, e.g., development of hatchery technologies, feeds, drugs, new products, packaging and handling, and should be encouraged to undertake and support research through appropriate policies and incentives. Furthermore, it would be useful to establish a policy that outlines the roles of the public and the private sectors in conducting and supporting research. For example, the public sector could give priority to research on development, policy, socio-economic and management related areas, and the private sector to research on market-led and commercially important areas, e.g., drugs, chemicals, feeds, seed production, posthavest handling, and product development.

The issues and constraints seem to suggest that consultative and/or participatory processes in setting research priorities are not effective, and existing efforts in disseminating research outputs and technology transfer are insufficient and/or ineffective, indicating underutilization of technological innovation. There is need to investigate causes for the ineffectiveness of existing processes and to facilitate active participation of fishfarmers and policy planners in identifying and formulating research projects and programmes, thus making research more relevant to user needs. Furthermore, there is need to better understand conditions and processes of assimilation, and identify the inhibiting factors in technology adaptation and utilization, so that effective and efficient utilization of research findings can be facilitated.

It appears that the aquaculture research sector suffers from lack of long-term planning and funding. Low level of support given to aquaculture research has been identified as one of the key constraints. This does not appear to be consistent with the increasing importance given to role of aquaculture in national food security and generation of income and employment opportunities in coastal and rural communities. To increase political support, it may be necessary for the sector to raise awareness of the public and policy makers of the benefits of aquaculture and aquaculture research. Further attention to problem-solving and policy-relevant research could help in securing and increasing support for aquaculture research.

Aquaculture has been said to be a victim of its own success; i.e., many of problems confronting aquaculture development have resulted from its rapid but unplanned growth. It appears that the sector has not had time to accumulate adequate information and knowledge bases that are required to support management actions. The policies and regulations often arrive late, and do not guide and encourage environmentally sound and socially responsible aquaculture. Institutional arrangements and capacity do not appear to have adjusted to meet the requirements of the fast growing sector. Management approach is often reactive rather than proactive.

Management of aquaculture has became a complex task, involving all levels of governments and many disciplines. Additionally, aquaculture is affected by and affects the actions of other sectors that utilize the same resources, i.e., land and water. A concerted effort is required to build up tools and knowledge base that will enable the sector to address economic, development, environmental, legal and social issues as well as technical issues. There is a need to further emphasize intersectoral, multidisciplinary and precautionary approach to the management and development of aquaculture.

It appears that the tendency to emphasize technological solutions as the means of promoting aquaculture development and deriving economic benefits, has overlooked the need to study economic and social dimensions of intensified production systems and the effects of technological approaches on development. It has been reported that one of the primary goals of aquaculture development is to contribute to social and economic well-being. It is important to have better understanding of impacts of the aquaculture development policies on availability of affordable fish food for local and domestic consumption, creating income and employment opportunities for rural communities, women and small scale fishfarmers, and use the findings as inputs to future policy and program planning.

Contrary to the general view that the issues relating to economic, social, legal, policy and management fall outside the aquaculture research programmes or are non-researchable, it is necessary to complement research on technology with research on socio-economics. This is because application of technological innovations must take into account environmental and socio-economic impacts and implications. More importantly, appropriate policies and institutional arrangement must be in place to facilitate development and application of technological innovations.

Table 18. Regional summary of aquaculture development and research priorities, issues & constraints, research programmes and on-going projects

Activities	Aquaculture Development Priorities	Issues & Constraints in Aquaculture Development	Aquaculture Research Priorities	Research Areas Recommended by Regional Fora	National Research Programmes	On-going national Project No.	On-going national Project %	Programmes of Reg. Fishery Bodies
Breeding & seed production	CPR, DRK, HOK, IND, INS, IRA, MAL, NEP, PHI, SRL, THA, VIE	BGD, CPR, IND, INS, MAL, PHI, SRL	BGD, CPR, DRK, IND, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE	BOBP-96; Sustainability-95; ASEAN-94; Environment-94	all countries	40	12.1	AIT; SEAFDEC/AQD
Culture sites, Identification & expansion	CPR, HOK, IND, INS, MAL, NEP, PAK, SRL, THA	HOK, IND, SRL	HOK, INS					
Environmental management & biodiversity	CPR, DRK, HOK IND, INS, IRA, MAL, PHI, STHA, VIE	CPR, HOK, IND, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE	BGD, CPR, DRK, HOK, IND, INS, MAL, NEP, PHI, SRL, THA, VIE	Shrimp-96; Commercial/shrimp-96; Legal-96; BOBP-96; Kyoto-95; Sustainability-95; Environment-94; IPFC/experts-94; ASEAN-94; ADSEA-94; Experts/Rome-94; NACA/TAC-92	all countries	30	9.1	AIT; ICLARM; NACA; SEAFDEC/AQD
Fish nutrition & feed development	CPR, HOK, IND, INS, MAL, PHI, SRL, VIE	BGD, IND, INS, MAL, PAK, PHI, SRL	BGD, CPR, DRK, HOK, IND, INS, IRA, MAL, NEP, PHI, THA	Shrimp-96; BOBP-96; Sustainability-95; Environment-94; ASEAN-94; NACA/TAC-92	all countries	28	8.5	AIT; SEAFDEC/AQD
Genetic improvement	CPR, DRK, IND, MAL, PHI, THA		BGD, CPR, DRK, IND, INS, IRA, NEP, PAK, PHI, THA, VIE	Shrimp-96; Sustainability-95; Seaweed-95; IPFC/experts-94; ASEAN-94; Environment-94; NACA/TAC-92	all countries	38	11.5	AIT; ICLARM; SEAFDEC/AQD
Health management	CPR, DRK, HOK, IND, PHI, SRL, THA, VIE	CPR, HOK, IND, INS, MAL, PHI, SRL	BGD, CPR, HOK, IND, INS, IRA, MAL, NEP, PHI, SRL, THA, VIE	Shrimp-96; Chemicals-96; BOBP-96; Sustainability-95; Environment-94; Disease-93	all countries	41	12.4	AAHRI; AIT; NACA; FAO SEAFDEC/AQD
Infrastructure & facility development	BGD, DRK, IND, INS, IRA, MAL, PAK, PHI, SRL, THA	CPR, IND, NEP, PAK, SRL			n/a	3	0.9	
Aq. engineering, e.g., design of pond, pen, cage, water recycling systems, etc.		VIE	HOK, IND, MAL					
Use of inland waters & stock enhancement	CPR, DRK, IRA, MAL, NEP, PAK, PHI, SRL	IND	BGD, DRK, IND, INS, NEP, PAK, SRL	Kyoto-95; Sustainability-95; ASEAN-94; Experts/Rome-94; NACA/TAC-92	all countries	8	2.4	AIT; NACA; SEAFDEC/AQD

(Table continues)

Activities	Aquaculture Development Priorities	Issues & Constraints in Aquaculture Development	Aquaculture Research Priorities	Research Areas Recommended by Regional Fora	National Research Programmes	On-going national Project No.	On-going national Project %	Programmes of Reg. Fishery Bodies
Legislation, regulations & policies	CPR, HOK, INS, MAL, PHI, SRL, THA, VIE	BGD, HOK, IND, INS, MAL, NEP, PHI, SRL, THA, VIE	DRK, PHI, SRL	Shrimp-96; Commercial/shrimp-96; Legal-96; Sustainability-95; IPFC/experts-94; Socioeconomics-94; Experts/Rome-94;	All countries except NEP; PAK; SRL; VIE	4	1.2	AIT; FAO/RAP; ICLARM
Marketing & market development	BGD, CPR, PAK, THA, VIE	IND, MAL, NEP, PAK, THA, VIE						
Postharvest handling & product development	CPR, IND, MAL, PAK, VIE	IND, MAL, NEP, PAK	BGD, CPR, VIE	Seaweed-95; ASEAN-94; Experts/Rome-94; Postharvest-94	All countries except NEP; PAK; VIE	3	0.9	FAO/RAP; SEAFDEC/AQD SEAFDEC/MFRD
Socio-economic assessment & interventions	BGD, CPR, IND, INS, NEP, PAK, PHI, SRL, THA	BGD, IND, HOK, MAL, NEP, PAK, PHI, SRL, THA, VIE	BGD, IND, NEP	Shrimp-96; Commercial/shrimp-96; Women-96; BOBP-96; Women-95; ASEAN-94; ADSEA-94; Experts/Rome-94; Socioeconomics-94;	All countries except NEP; PAK; SRL; VIE	5	1.5	AIT; FAO/RAP; IFOFISH; SEAFDEC/AQD
Species diversification	CPR, DRK, HOK, INS, MAL, SRL, THA		DRK, HOK, MAL, VIE		All countries	32	9.7	AIT; ICLARM; SEAFDEC/AQD
Stock assessment & population dynamics	PHI		BGD, DRK, PAK, PHI, SRL					MRC; SEAFDEC/AQD
Technology transfer & extension	BGD, CPR, IND, INS, IRA, NEP, PAK, PHI, THA, VIE	BGD, CPR, HOK, IND, INS, IRA, MAL, NEP, PAK, PHI, SRL, THA, VIE			all countries	16	4.8	
Culture & technology development	All countries	all countries	All countries	Shrimp-96; Legal-96; Sustainability-95; Seaweed-95; ASEAN-94; Experts/Rome-94; NACA/TAC-92	all countries	71	21.5	AIT; NACA; ICLARM; MRC; SEAFDEC/AQD
• Integrated fish farming	CPR, IND, MAL, NEP, SRL		BGD, IND, PHI, SRL					
• Intensification of culture systems	CPR, IND, INS, PHI, VIE		BGD, DRK, IND, PAK					

In this connection, it would be useful to recall the shortcomings in aquaculture research strategies and capacities that were highlighted by the SIFR evaluation exercise in the late 1980s. The SIFR studies expressed concerns over the institutional organization of the research system; the nature and appropriateness of the science activities being carried out; and the effectiveness in delivering research outputs and communicating with end-users concerned. Specific shortcomings mentioned in the SIFR studies include resources spread across too many institutions; inappropriate resource allocation; poor integrated strategies and coordination mechanisms; lack of multidisciplinary staff resource; lack of long-term funding support; low motivation; quality and relevance of training; communication gap between public sector institutes, universities and production sector; inappropriate dissemination mechanisms; top-down approaches and unrealistic demonstrations in technology transfer; and relevance and effectiveness of research outputs.

Many issues and constraints revealed in this study are disconcertingly similar to the weaknesses pointed out by the SIFR studies, suggesting that little change in the sector management has been made since late 1980's, except increased awareness of shortcomings and needed changes, and reactions to urgent external pressures such as environmental degradation, social and resource (i.e., land and water) use conflicts, strict quality control for consumer safety.

6. RESEARCH OPPORTUNITIES OF COMMON CONCERNS

The objectives of national aquaculture development and the issues and constraints in aquaculture development suggest a number of researchable areas suited for regional cooperation (Table 19).

In order to ensure relevance of research to sustainable aquaculture development, the process of identifying research opportunities of common concerns was guided mainly by the objectives of aquaculture development and common key constraints that emerged from the survey. Additionally, consideration was given to the need for an enabling environment, e.g., institutional arrangements and policy frameworks that foster sound aquaculture development research and provide guidance to aquaculture managers, planners and other concerned parties in making decisions.

Many of the current problems in aquaculture are of managerial and socio-economic nature, and solutions to some of the major problems in aquaculture may have to be found outside the traditional aquaculture disciplines through multidisciplinary and intersectoral research.

The aquaculture sector, which has often been said to lie in a grey area between agriculture and fisheries, does not seem to have had time to accumulate appropriate tools and adequate knowledge base for policy planning and management decisions. Furthermore, due to weak interagency linkages and the lack of appropriate policies and organizational frameworks, the countries are not able to optimally utilize human, financial and physical resources, and benefit fully from technological innovations.

The region collectively has a significant number of organizations and personnel that can undertake research on technical aspects, although they are not evenly distributed. Research on various technical areas and production systems could effectively be supported through the existing national and regional research programmes. For instance, since many diseases are closely linked to deteriorating environmental conditions, prevention of diseases through management of the aquatic environment, in the context of a systems approach, rather than treatment by drugs, should be the main approach in disease control and health management. Additionally, the private sector could realistically conduct and support research on market-led and commercially important areas such as development and

production of aquaculture equipment, vaccines, drugs, chemicals, feeds, seeds and new value-added consumer products.

Thus, the following seven areas (three in the areas of institutional and socio-economic aspects and four in technical aspects) have been identified, for consideration by the countries, as priority research opportunities for regional collaboration:

A. Institutional and Socio-economic Aspects[7]

Planning and management of aquaculture development and research

- Policies and strategies for improved participatory planning, interagency linkages and institutional arrangement for improved intersectoral and multidisciplinary coordination and collaboration
- Strategies for targeted, field- and policy-oriented research
- Study on methods and mechanisms for improved technology transfer and information dissemination and sharing
- Assessment of human resource requirements and strategies for human resource development
- Strategies for mobilizing human and financial resources for aquaculture development and research

Social and economic assessment of aquaculture

- Methodologies and guidelines for social impact analysis
- Cost benefits of aquaculture systems
- Impacts of aquaculture development policies, on food security, income and employment generation, livelihood of small-scale and/or subsistence fishfarmers, gender and equity
- Macro- and micro-economic policy requirements for sustainable aquaculture
- Strategies for improved postharvest handling and product development, including distribution, marketing and relationships between fishfarmers and middlemen

Legislative framework for aquaculture

- Guidelines for application of existing laws to aquaculture
- Guidelines and strategies for formulating aquaculture legislation

B. Technical Aspects[8]

Environmental management of in aquaculture

- Methodologies for environmental impact assessment (EIA) of coastal aquaculture
- Siting protocols and guidelines for aquaculture zoning
- Environmental standards for aquaculture effluents and water quality
- Codes of practice for farm management

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[7] Two of twenty-eight SEAFDEC/AQD projects planned for 1998 are concerned with impact analysis and socio-economic indicators in evaluating the community fisheries resource management projects.

[8] Efforts are underway to formulate and implement regional projects/programmes addressing various technical issues relating to health and environmental management, e.g., Code of Conduct for Responsible Shrimp Farming in Asia by NACA/FAO; ADB/NACA Coastal Aquaculture Disease Control and Management; FAO/NACA Regional Programme for the Development and Implementation of Health Certification and Quarantine Guidelines for the Responsible Movement of Aquatic Animals in the Asia-Pacific Region; WHO/FAO/NACA Study Group on Food Safety Issues Associated with Products from Aquaculture. Additionally, AIT, ICLARM, MRC and SEAFDEC/AQD programmes includes research projects in the areas of breeding, feed, genetics, health and environmental management, postharvest handling and product development, and marketing.

Fish health management

- Disease diagnosis and control methods
- Strategies for disease control and prevention
- Epidemiological assessment

FISH nutrition and feed development

- Formulation of low cost and farm-made feeds
- Feeding optimization

Breeding & broodstock management

- Culture species diversification
- Broodstock improvement

Table 19. Indicative research opportunities to address the common issues and constraints of the countries

Aquaculture development objectives	Main common issues and constraints	Possible research opportunities
• Increased productivity and aquaculture production (first priority of 9 countries) • Employment generation (first priority of 1 country) • Supply of quality fish food for domestic needs (first priority of 2 countries) • Increased income for fishfarmers • Improved export earning • Industrialization and modernization of aquaculture (first priority of 1 country) Minimization of ecological damage & impacts • Improve quality of life for small scale fishfarmers (first priority of 1 country) • Expansion or identification of new culture areas/sites	• Weak institutional and organizational linkages, and coordination and collaboration among related agencies and programmes • Inadequate consultation with planners, implementers and users of research outputs	Understanding of aquaculture management and planning, including functional relationships among the agencies and organizations within aquaculture and with the organizations and sector outside aquaculture; policies and strategies for improved interagency linkages and institutional arrangement for improved intersectoral and multidisciplinary coordination and collaboration; protocols and mechanisms for multidisciplinary, intersectoral and coordinated planning and management; strategies for targeted, field-oriented, policy-relevant research; mechanisms and processes for improved consultation
	• Ineffective technology transfer • Lack of appropriate methods and mechanisms for information delivery and sharing	Understanding of causes for ineffective technology transfer and underutilization of research outputs; methods and mechanisms that facilitate effective technology transfer; communication channels, and sources and flow of information in aquaculture; weakness in existing aquaculture information programmes and services; appropriate mechanisms and methods for effective dissemination and exchange of information
	• Insufficient skilled technical and research human resources • Lack of opportunities and resources for (advanced) training of personnel	Assessment of human resource requirements; strategies for human resource development, particularly critical masses of expertise in target areas; strategies and policies for optimal utilization of the existing human resources and expertise; quality and relevance of training in the context of the national aquaculture development needs
	• Inadequate research facilities & supplies • Low level of research funding • Low priority given to aquaculture research	Increase awareness of the role of aquaculture in food security, economy and employment, and the needs for research to support aquaculture development; strategies and mechanisms for securing continuity in funding and diversifying sources of funds; improvement in resource allocation; strategies for developing core aquaculture research organizations

Aquaculture development objectives	Main common issues and constraints	Possible research opportunities
	• Pollution of aquatic environment and ineffective monitoring and control	Understanding the issues, identification of main sources of pollutants, and strategies for better control and monitoring of pollutants, including mechanisms for coordination and cooperation with agencies and sectors dealing with the pollutants; strengthen regulations and monitoring mechanisms; integrated area management and environmental impact assessment (EIA) of aquaculture; siting protocols and guidelines for aquaculture zoning; environmental standards for aquaculture effluents and water quality
	• Lack of or inadequate aquaculture technologies	Technology assessment and adaptation; methodologies for environmental impact assessment; environmentally sound and socially responsible culture systems and technologies; disease diagnosis and control methods; epidemiological assessment; strategies for disease control and prevention; low cost and farm made feeds; feeding strategies and optimization; culture species diversification; broodstock development; strategies for enhancing natural stocks
	• Inadequate legislation, regulation, policies, and lack of socio-economic assessment and management interventions	Guidelines for application of existing laws to aquaculture; guidelines and strategies for formulating aquaculture legislation; methodologies and guidelines for social impact analysis; cost benefit of aquaculture systems and production economics; impacts of aquaculture development policies, particularly on food security, income and employment generation, livelihood of small-scale and/or subsistence fishfarmers, gender and equity; macro- and micro-economic policy requirements for sustainable aquaculture; strategies for improved postharvest handling and product development, including distribution, marketing and relationships between fishfarmers and middlemen; strategies for mobilizing human and financial resources for aquaculture development and research; relevance of research programmes and priorities in the context of national and local development needs

7. CONCLUSION

The survey revealed common concerns in aquaculture development and research of the fourteen Asian countries and provided a basis for identifying regional/sub-regional research opportunities. The survey responses did not reveal new information, rather it confirmed the weaknesses and needs identified by previous studies, emphasizing the need for collective actions in support of management and development of environmentally sound and socially equitable aquaculture.

Although not evenly distributed, the countries collectively have considerable aquaculture research capacities and resources that a regional cooperative activity could utilize. Furthermore, the needs and stages of aquaculture development vary among the countries. An incremental or step-by-step approach could be taken in development and implementation of the regional actions, so that these need not be contingent on participation of all countries or availability of external funding support.

Regional cooperative action plans should be formulated and implemented on the basis of the interests and commitment expressed by the countries. NACA and FAO, in collaboration with other relevant regional and international bodies, could facilitate the regional consultation processes in formulating action plans. It should be borne in mind that regional actions do not replace or duplicate the national actions and efforts, rather they support and complement national actions under a regional scheme.

It has been noted that some countries are reluctant to disclose the details of their aquaculture research programmes, perhaps due to some economic interests at stake and the market competition with others. To ensure formulation of action plans that are truly cooperative and beneficial to all participating countries, it is necessary for the countries to address this issue, and define the nature and types of regional collaborative and cooperative research that they would support and participate in.

Formulation of action plans and project proposals should take into account the needs of field-oriented, problem-solving and policy-relevant research, and should involve the active participation of the private sector, local and fishfarming communities, policy-planners and implementors.

Finally, it should be kept in mind that success of regional collaborative research depends on the commitment of the participating countries. The countries must be prepared to play a central role in determining the research activities and methodologies, as well as the implementation and management of regional collaborative research. The role of the regional and international bodies, including funding agencies, should be that of a catalyst and facilitator.

8. REFERENCES

1. ACIAR/DOF/NACA. 1996. Report of the workshop on "Key Researchable Issues in Sustainable Coastal Aquaculture in Thailand", Songkhla, Thailand, 28-31 October 1996. (Unpublished).

2. ADB/NACA. 1996. Aquaculture Sustainability Action Plan. Regional Study and Workshop on Aquaculture Sustainability and the Environment (RETA 5534). Asian Development Bank and the Network of Aquaculture Centres in Asia-Pacific. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand. 21p.

3. AFS/FHS. 1993. Report of the workshop on "Priorities for Disease Research: Towards Minimizing Losses from Disease in Asian Aquaculture," The Session on SIFR and the Need for Demand-Led Research, held at the Second Symposium on Diseases in Asian Aquaculture: Aquatic Animal Health and the Environment, Phuket, Thailand, 25-29 October 1993. (Unpublished).

4. ASEAN. 1994. Report of the Conference on Fisheries Management and Development Strategies for the ASEAN Region for the Year 2000, Bangkok, Thailand, 26-29 1994. ASEAN.

5. Barraclough, S. and Andrea Finger-Stich. 1996. Some Ecological and Social Implications of Commercial Shrimp Farming in Asia. UNRISD DP 74. UNRISD. 62p.

6. BOBP. 1996. Towards Sustainability: Needs and Constraints of and Project Ideas to Facilitate Sustainable Management of Aquatic Resources and Fisheries in the Bay of Bengal Region: a report submitted to the IOFC Committee for the Development and Management of Fisheries in the Bay of Bengal (BOBC). BOBP, Madras, India.

7. Charles, A. T.; T. R. Brainerd; M. A. Bermudez; H. M. Montalvo; R. S. Pomeroy. 1994. Fisheries Socio-economic in the Developing World: Regional Assessments and an Annotated Bibliography. IDRC, Canada. 163 p.

8. FAO. 1996. Regional Review of the Fisheries and Aquaculture Situation and Outlook in South and Southeast Asia. *FAO Fisheries Circular* No. 904. FAO, Rome. 45p.

9. FAO. 1996a. Production. Vol. 49. *FAO Statistics Series* No. 130, 1995. Rome, FAO.

10. FAO. 1996b. Fishery statistics: catches and landings, 1995. Vol. 80. *FAO Fisheries Series* No. 48, *FAO Statistics Series* No. 134. Rome, FAO. 713p.

11. FAO. 1996c. Aquaculture production Statistics, 1986-1995. *FAO Fisheries Circular* No. 815 (Rev. 9). Rome, FAO. 195p.

12. FAO. 1996d. Fish and fishery products - apparent annual consumption statistics based on food balance sheets (1961-1993). *FAO Fisheries Circular* No. 821 (Rev. 3). Rome, FAO. 235p.

13. FAO. 1996e. Fishery statistics - commodities. Vol.81. *FAO Fisheries Series* No. 45; *FAO Statistical series* No. 124. Rome, FAO. 183p.

14. FAO/Govt. Japan. 1996. Kyoto Declaration. International Conference on the Sustainable Contribution of Fisheries to Food Security, Kyoto, Japan, 4 to 9 December 1995. 22p.

15. FAO/SEAFDEC AQD. 1996. Report of the International Expert Meeting on the Use of Chemicals in Aquaculture, Iloilo, Philippines, 20-22 May 1996. (In press).

16. FAO. 1995. Code of Conduct for Responsible Fisheries. FAO, Rome. 41p.

17. FAO. 1994. Expert Consultation on Fishery Research, Rome, 12-15 April 1994. (Unpublished)

18. FAO/NACA. 1995. Regional Study and Workshop on Environmental Assessment and Management of Aquaculture Development (TCP/RAS/2253). *NACA Environment and Aquaculture Development Series* No. 1. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand. 492p.

19. FAO/RAP. 1994. Report of the Eighth Session of the IPFC Working Party of Experts on Aquaculture, 24-25 Oct. 1994. (Unpublished).

20. Insull, D. and Z. Shehadeh. 1996. Policy directions for sustainable aquaculture development. FAO Aquaculture Newsletter. No. 13: 3-8.

21. International Law Institute/NACA. 1996. Report of the Workshop on Legal and Regulatory Aspects of Aquaculture in India and Southeast Asian Countries, Bangkok, 10 to 13 March 1996. (Unpublished).

22. NACA. 1995. Regional Study and Workshop on the Taxonomy, Ecology and Processing of Economically Important Red Seaweeds., Bangkok, 24-27 January 1995.

23. NACA. 1992-1996. Reports of the Meetings of the NACA Technical Advisory Committee, 1992, 1993, 1994, 1996.

24. PADEK. 1996. Report of the Seminar on the Role of Women in Fisheries in Indo-China Countries, Phnom Penh, 6 to 8 March 1996. (unpublished).

25. SEAFDEC/JICA/CIDA. 1995. Towards Sustainable Aquaculture in Southeast Asia and Japan. Proceedings of the Seminar-Workshop on Aquaculture Development in Southeast Asia, held in Iloilo, Philippines, from 26 to 28 July 1994. SEAFDEC, Philippines. 254p.

26. SIFR. 1994. A Strategy for Post Harvest Fisheries Research in Asia. SIFR, Canada

27. UNDP/Government of the Philippines. 1995. Regional Workshop on the Role of Women in Fisheries Development, Iloilo City, Philippines, 17-21 July 1995.

28. World Bank/UNDP/CEC/FAO. 1992. A study of International Fisheries Research. *Policy and Research Series* No. 19. The World Bank, Washington, D.C. 103p.

29. World Bank/UNDP/CEC/FAO. 1991. Tropical Aquaculture Development: Research Needs. *World Bank Technical Paper* No. 151. Fisheries Series. The World Bank, Washington, D.C. 52p.

30. World Bank/UNDP/CEC/FAO. 1991. Fisheries and Aquaculture Research Capacities and Needs in Asia: Studies of India, Thailand, Malaysia, Indonesia, the Philippines, and the ASEAN Region. *World Bank Technical Paper* No, 147. *Fisheries Series.* The World Bank, Washington, D.C. 70p.

Annexes

Annex 1
Survey Forms

SECTION I: STATUS OF AQUACULTURE DEVELOPMENT

[To be completed by the agency that has over all responsibly for the national aquaculture development]

Country: _____

Responding Agency

Name: _____

Address: _____

_____

Tel. No. _____

Fax No. _____

Telex: _____

E-Mail: _____

Name of contact person: _____

Title of contact person: _____

A. Please describe **importance of aquaculture sector to the national development** (please ***attach sections of the national development plan and the policies and development plans of such sectors as agriculture, fisheries, environment and industry that are relevant to aquaculture development***).

_____

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B. Please provide following data, using **the latest statistics of year 199___** (please insert the year)

Total aquaculture production _____ tons; Total aquaculture production area: _____ha
Contribution of aquaculture sector to GNP _____%; _____ (Amt in local currency);
Number of people directly employed in aquaculture sector _____ persons

C. Please state the **objectives** and **the priority areas of *present* national aquaculture development plan.**

Objectives	Priority areas

(Please attach additional sheet(s) if needed)

D. Please **describe Action Plans for Implementation of *present* National Aquaculture Development Plan.** Dated the current action plans were adopted; _____

Title of Action Plan	Objectives	Expected Results	Target Beneficiaries

(please attach additional sheets as needed)

E. Please describe **Processes followed in Setting development priorities and formulating action plans.**

Processes Followed (indicate who initiates the process)	Criteria* used in setting aquaculture develop. Priorities & Action plans	Participants (main types of agencies, inst., org., interest groups, etc.) and Role of Each Participating Group

* - Indicate in descending order of importance.

F. Please describe **Stages of Implementation of *Present* National Aquaculture Development Plan**

Action Plans (see D above)	(Planned) Implementation Date	Name of Implementing Agency	Participants (types of agencies, inst., org., groups, etc.) and Role of each Participating Group	Resource Allocated

(please attach additional sheets as needed)

G. What are the **Effects Resulting from Implementation of National Aquaculture Development Plan**?

Action Plans (see D above)	Changes and Effects Resulting from implementation of the action plans	Emerging Issues	Adjustments or new actions introduced/ proposed

(please attach additional sheets as needed)

H. Are there **critical aquaculture development needs that are not addressed by the existing aquaculture development programs and projects**? If there are, please describe them with indication of possible course of action.

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Please attach three (3) most important recent papers that provide reviews, assessment and/or overviews of current national aquaculture development plan.

I. Please describe **Issues and Needs of national Aquaculture Development**, using general headings provided. Please **be specific** in your description, identifying types and areas of concerns.

Category	Issues*	Causes & Constraints	Actions needed to remove the causes & Constraints
Administration & Institutional (e.g., lack of support for aquaculture; lack of or inadequate aquaculture development plan; lack of coordination among related agencies & programs, etc.)			
Legal (e.g., conflicting or overlapping jurisdictions; lack of regulation on sitting or zonation; etc.)			
Information (e.g., ineffective technology transfer; under- or ineffective utilization of information; inadequate access and unavailability; lack of exchange & sharing; lack of appropriate information delivery methods and mechanisms; etc.)			
Human Resources (e.g., lack of skilled personnel in specific areas, underutilization of skills of certain groups; etc.)			
Technical (e.g., difficulty in obtaining fish feed ingredients; lack of management guidelines on specific areas such as effluent treatment, etc.)			
Physical environment (e.g., no appropriate sites for aquaculture; pollution or other environmental factors affecting aquaculture, etc.)			
Socio-economics (e.g., difficulty in getting credit; lack of market; low price; lack of participatory decision making & management; etc.)			
Others (please specify)			

(please attach additional sheets if needed)

*** - Please list in descending order of importance**

J. **Structure of Aquaculture Sector** (please draw or attach a chart showing relationships among agencies, organizations and institutions, both public and private sectors, involved in aquaculture development and research).

K. Please List **On-Going and Planned Aquaculture Development Programmes/Projects** (please list regional and international cooperative programmes and projects separately under item K.)

Title of Develop. Prog. & Proj.	Duration: From-To	Objectives	Target Beneficiaries	Executing Agency/ies	Participating organizations & their role	Budget Local*	Budget External**

(please use additional sheets if needed)

* - Indicate amount in local currency and source of funding in parenthesis, e.g., Baht xxxxx (Dept. of Fisheries)
** - Indicate amount in US$ and source of funding in parenthesis, e.g., US$ xxxxx (ADB)

L. Please List **On-Going and Planned Regional and International Aquaculture Development Programmes/Projects in which your country participates.**

Title of Reg./ Int. Prog. & Proj.	Duration: From-To	Objectives	Target Beneficiaries	Executing Agency/ies	Participating organizations & their role	Budget Local*	Budget External**

(please use additional pages as needed)

* - Indicate amount in local currency and source of funding in parenthesis, e.g., Baht xxxxx (Dept. of Fisheries)

** - Indicate amount in US$ and source of funding in parenthesis, e.g., US$ xxxxx (ADB)

SECTION II. NATIONAL AQUACULTURE RESEARCH SECTOR

[To be completed by the agency responsible for planning and coordination of national aquaculture research sector]

Responding Agency

Name: _____

Address: _____

_____

Tel. No. _____

Fax No. _____

Telex: _____

E-Mail: _____

Name of contact person: _____

Title of contact person: _____

Main Functions: _____

_____

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A. Please describe Goals and Objectives of Aquaculture Research Sector (please ***attach sections of the national aquaculture development plan and the policies and development plans of agriculture, fisheries, environment and industry sectors that are relevant to aquaculture development research***).

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B. Please describe main role of research organizations:

Public Sector: _____

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Private Sector: _____

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C. Please describe **Priority Research Areas and Action Plans and Programmes** (Please note that for each priority research area, there could be several action Plans and Programmes.)

Priority Research Areas	Action Plans & Programmes	Expected Outputs	Target Beneficiaries	Date implemented	Implementing Organization	Participating Organization(s)	Budget Local*	Budget External**

(please use additional sheets if needed)

* - Indicate amount in local currency.
** - Indicate amount in US$.

D. Please describe **Processes followed** in determining Aquaculture Research Priorities and formulating Action Plans and Programs

Processes Followed (indicate how & who initiates the processes)	**Criteria* used in setting research priorities and action plans**	**Key Participants (types of inst., org., groups, etc.) and Role of Each participating Group**

*- Indicate in descending order of importance

E. Are there urgent aquaculture research needs that are not addressed through existing research programs and projects? If there are, please them with suggestions for action.

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Please provide three most important recent papers that provide overviews and assessment of National Aquaculture Research Sector.

F. Please describe **Methods and Medium** that are used regularly to **Disseminate and Transfer Research Outputs to the following target groups.** Please indicate N/A if research outputs are not disseminated to specific target group.

Target Groups	Methods and Medium	% of res. outputs targeted for each group
Policy Planners, Political level		
Administrators & Managers of Government Agencies		
Fish-Farming Community, small & medium scale & community level		
Private Sector & Supporting Industries, including investment banks		
Research Community		
Extension Community		
Public In General		
Other (please specify)		

G. Please describe **National Aquaculture Research Capacity**

Names and Addresses of Key Aquaculture Research Organizations in the Country	Institutional Affiliation*	Areas of Concentration and/or Special Competence**

(Please attach additional sheets if needed)

*- Indicate the ministry under which the organization is affiliated.

** - **One organization may have more than one area of concentration or special competence**, e.g., all aspects of seaweed production & processing; ornamental fish breeding and disease control; fish nutrition; product development -shrimp; environmental management - waste water treatment; integrated farming systems; legal and regulatory aspects; etc.

H. Please describe **Issues and Needs in implementing national aquaculture research programs,** using general headings provided. Please **be specific** in your description, identifying types and areas of concerns.

Category	Issues*	Causes & Constraints	Actions needed to remove the causes & Constraints
Administration & Institutional (e.g., low priority given to aquaculture research; inappropriate adequate research priorities; lack of coordination among related agencies & programs; ineffective research management; etc.)			
Legal (e.g., conflicting or overlapping jurisdictions; etc.)			
Information (e.g., ineffective technology transfer; under- or ineffective utilization of information; inadequate access and unavailability; lack of exchange & sharing; lack of appropriate information delivery methods and mechanisms; etc.)			
Human Resources & Research Competence (e.g., lack of skilled personnel in specific areas, low capacity to identify, formulate and implement research programs & projects; difficulty in attracting & motivating aquaculture researchers; etc.)			
Research facilities (e.g., inadequate equipment; difficulties in obtaining special supplies, etc.)			
Research Environment (e.g., no or little dialogue between research institutions and their clients, e.g., users of research outputs; etc.)			
Others (please specify)			

(please attach additional sheets if needed)

*** - Please list in descending order of importance.**

I. Please Indicate **adequacy of national aquaculture research capacities in meeting national aquaculture development needs.**

National Aquaculture Development Priority	Priority Research Needs	Adequacy** of Research Capacity		
		Res. Facilities	Res. Personnel No.	Skills

(Please attach additional sheets if needed.)

Please note that for each of national aquaculture development priority, there could be several priority research needs.

* - Please indicate in descending order of importance

** - Indicate adequacy of **research facilities**, and **number and skills of research personnel** using the scales **1=No capacity; 2=Very inadequate; 3=Fairly adequate; 4=Good; 5=Excellent capacity.**

SECTION III. SURVEY OF AQUACULTURE RESEARCH ORGANIZATIONS

[To be completed by individual organizations, both in public and private sectors, that have aquaculture research as one of the core programs of the organization.]

Responding Organization

Name: _____

Affiliation: _____

Address: _____

_____

Tel. No. _____

Fax No. _____

Telex: _____

E-Mail: _____

Name of contact person: _____

Title of contact person: _____

I. Please describe **Missions and Mandates of your organization**

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II. Please state the **Goals and Objectives of Aquaculture Research Program** of your organization.

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III. Please describe **main aquaculture program areas, research priorities, research capacities of your organization**. Please note that each main program could have more than one research priority area.

Title of Main Res. Programs	Priority Res. Areas	Main Objectives	Date established	Personnel				Major Research Facilities**		Funding+		
				Researchers		Res. Assist.*				Core++	External+++	
				F-T	P-T	F-T	P-T	Phy. Facilities	Equipment	Amt.	Amt.	Source

(Table continues on the next page)

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* - Research Assistants, including labratory & field technical assistants.

** - Physical facilities: Field stations, laboratories, storage facilities, hatcheries, etc.; Equipment: Name and description of equipment and indicate quantity in parenthesis, e.g. liquid chromatography with description of capacity (number available).

+ - If it is not easy for you to break down the funds by major aquaculture research programs, please give figures for whole aquaculture programs.

++ - Please indicate in local currency. +++ - Please indicate in US$ and name of funding organization (s).

Title of Main Res. Programs	Priority Res. Areas	Main Objectives	Date established	Personnel				Major Research Facilities**		Funding+		
				Researchers		Res. Assist.*				Core++	External+++	
				F-T	P-T	F-T	P-T	Phy. Facilities	Equipment	Amt.	Amt.	Source

(Please attach additional sheet(s) if needed)

IV. Please describe the **processes and criteria** (e.g., areas of research competence of the organization; farmers' or local needs; scientific merits and contribution to scientific knowledge; national developmental needs and priorities; donor funding criteria; mandates and objectives of the organization; scientific interest of individual researcher; requests by clients; etc.) **used in formulating aquaculture research program and projects** of your organization.

Processes Followed	Criteria* used in Formulating Research Programs & Projects	Key Participants in Formulating Research Prog. & Proj. & their Role

(Please indicate in descending order of importance)

V. **Human Resources.** Please indicate part-time employees in parenthesis, i.e., number of fill-time staff (number of part-time staff).

	Ph D	M Sc	B Sc	Other (specify)	Other (specify)
Biological sciences					
Physical & Engineering Sciences					
Social Sciences					
Economics					
Legal Specialists					
Other (Please specify)					
Other (Please specify)					

VI. Please describe **Methods and Medium** that are used regularly to **Disseminate and Transfer Research Outputs to the following target groups.** Please indicate N/A if research outputs of your organization are not disseminated to specific target group.

Target Groups	Methods and Medium	% of res. outputs targeted for each group
Policy Planners, Political level		
Administrators & Managers of Government Agencies		
Fish-Farming Community, small & medium scale & community level		
Private Sector & Supporting Industries, including investment banks		
Research Community		
Extension Community		
Public In General		
Other (please specify)		

VII. What are the **issues** (e.g., low priority given to research; lack of skilled personnel; facilities; coordination and collaboration among related organizations and programs; lack of information exchange; lack of mechanisms & opportunities for disseminating research outputs; poor utilization of research outputs; lack of research in critical areas (specify the areas); lack of farmer participation in research priority setting; lack of research policies; etc.) and **actions required for improved effectiveness and efficiency of Aquaculture Research**? Please **be specific** in describing situation.

Issues*	Causes & Constraints	Actions Needs to Remove the Causes & Constraints

*** - Please list in descending order of importance**

VIII. Are there **urgent aquaculture development and research needs that are not addressed by existing programs and projects?** If there are, please list them and indicate possibilities for regional or sub-regional cooperative action.

IX. **List of On-Going and Planned Aquaculture Research Projects** (Please list regional and international projects which your organization participates in separately under item X.)

Title of Research Project	Duration: From-To	Objectives	Target Beneficiaries	Target Outputs	Participating organizations & their role	Budget Local *	Budget External**

(Please use additional sheets if needed)

* - Amount in local currency and source of funding in parenthesis, e.g., Bath xxxx (Ministry of Sci. & Tech.)
** - Amount in US$ and source of funding in parenthesis, e.g., US$ xxxx (GTZ)

X. **List of Regional and International Aquaculture Research Projects which your organization participates in.**

Title of Regional Research Project	Duration: From-To	Objectives (your Organization's)	Target Beneficiaries	Target Outputs	Role of Your Organization	Budget Local*	Budget External*

* - Amount in local currency and source of funding in parenthesis, e.g., Bath xxxx (Ministry of Sci. & Tech.)
** - Amount in US$ and source of funding in parenthesis, e.g., US$ xxxx (GTZ)

Annex 2

Names and Addresses of National Coordinators for Aquaculture Research Survey

Bangladesh	Mr. Shahab Uddin Senior Scientific Officer Bangladesh Fisheries Research Institute Freshwater Station, Mymensingh 2201 Tel No: (880-91) 54874; 54221; Fax No: (880-91) 55259
China	Ms. Cen Feng Head, Disease Control Division National Fisheries Technology Extension Centre Ministry of Agriculture No. 11, Nongzhanguan Nanli, Chaoyang District Beijing 100026 Tel No: (86-10) 6419 5072; Fax No: (86-10) 65074250
DPR Korea	Mr. Zo Gi Su Aquaculture Department Ministry of Fisheries Sochang-dong, Central District Pyongyang Tel No: (850) 3816 113; Fax No: (850) 814 439
Hong Kong China	Dr. Patsy Wong Agriculture and Fisheries Department Canton Road Government Offices 393 Canton Road, Kowloon Hong kong Tel No: (852) 27 33 22 00; Fax No: (852) 23 11 37 31
India	Dr. B.N. Singh, Director Central Institute of Freshwater Aquaculture PO Kausalyagang Bhubaneswar 751 002 Tel No: (91-674)463 446 ext 207; Fax No: (91-674) 463 407 E-mail :cifa@x400.nicgw.nic.in
Indonesia	Dr. Fuad Cholik Director Central Research Institute for Fisheries Jln K.S. Tubun, Palmerah Jakarta 11410A Tel No: (62-21) 570 9160; Fax No: (62-21) 570 9159
Iran I R	Mr. Mohammad Mazzloomi Jahad-E-Sazandegi Ministry No. 24, 11th Allay, Miremad St, Mothahari Ave Tehran 15877 Tel No: (98-21) 650 858; 651 603; Fax No: (98-21) 885 5370

Malaysia	Mr. Ismail Awang Kechik Department of Fisheries 11960 Batu Maung Pulau Penang Tel No: (04) 626 3925/6; Fax No: (04) 626 2210 E-Mail: fri@ipp.po.my
Nepal	Mr. Deep Swar Fisheries Development Officer Central Fisheries Building, Balaju, Kathmandu Tel No: (977-1) 270 609; Fax No: (977-1) 272 833
Pakistan	Dr. Rukhsana Anjum Asst. Fisheries Development Commissioner Ministry of Food, Agriculture and Livestock Livestock Division, 79 Al Rehman Chambers Sector G-7, Blue Area, Islamabad Tel No: (92-51) 922 1592; Fax No: (92-51) 922 1246
Philippines	Ms. Prescilla B. Regaspi Senior Aquaculturist Bureau of Fisheries and Aquatic Resources 880 Estuar Bldg, Quezon Avenue Quezon City, Metro Manila 3008 Tel No: (63-2) 922 2231; 929 8561; Fax No: (63-2) 922 2231
Sri Lanka	Dr. J.M.P.K. Jayasinghe Director, National Aquatic Resources Agency Crow Island, Mattakkuliya, Colombo 15 Tel No : (94-1) 522 005; Fax No: (94-1) 541 184
Thailand	Mr. Pinit Srihapitukgiat Director, National Inland Fisheries Institute Department of Fisheries Kasetsart University Campus Ladyao, Jatujak, Bangkok 10900 Tel No: (66-2) 562 0426; Fax No: (66-2) 579 6439
Vietnam	Dr. Pham Thuoc Deputy Director Research Institute of Marine Products 170 Le Lai Street, HaiPhong Tel No: (84-31) 836 005, 836 656; Fax No: (84-31) 836 812

Annex 3

Outline of Country Report

The following outline was prepared to ensure a consistency in the presentation of the country reports. Please follow the format as outlined, addressing each points and aspects noted and citing sources of your information. The title of your report should be "*Aquaculture Research Priorities and Capacities in your country*". NACA and FAO greatly appreciate your kind cooperation.

I. Background

Please provide a brief description of:

1. historical background, e.g., history of aquaculture in the country and aquaculture in social & cultural setting;
2. status of aquaculture and the needs for aquaculture development, highlighting following aspects:
   - main types of culture practiced, e.g., coastal aquaculture, pond culture, cage or pen culture, mariculture, culture based fisheries, key species cultured (please list 10 or 15 most important species, with production figures and ha used for culture),
   - demands for aquaproducts,
   - social & cultural importance, e.g., role of aquaculture in food security and livelihood
   - contribution of aquaculture to GNP, employment, export earnings, etc.

II. National Aquaculture Development Plan

II.1. Evolution of Aquaculture Development Planning

Please explain when and how national aquaculture development plan initiated and how the planning process has evolved or progressed.

II.2. Objectives and Priorities of the National Aquaculture Development Plan

Please explain objectives and priorities of the present national aquaculture development plan.

II.3. Processes Used in Formulating the Aquaculture Development Plans and Priorities

Please describe (a) the processes followed in formulating the national aquaculture development plans and priorities, including participating groups and organizations and their role, (b) sources of information for the planning, and (c) the criteria used in setting the priorities.

II.4. Implementation of the National Aquaculture Development Plans

Please describe:

- Strategies and action plans for implementation of the national aquaculture development plan, main beneficiaries, expected outputs and resources allocated for each action plans,
- Resulting changes and effects of the action plans, emerging issues and required actions and plans to address the emerging issues.

II.5. Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Please describe issues, constraints and needs in formulating and implementing the national aquaculture development plans, by highlighting the following aspects:

- Institutional and management aspects
- Legal aspects
- Coordination and cooperation (between related institutions and sectors)
- Information
- Human resources
- Technical aspects
- Physical and environmental aspects
- Socioeconomic aspects
- Others.

III. National Aquaculture Development Research

III.1. Role, Objectives and Priorities of the National Aquaculture Research

Please describe the role, objectives and priorities of the national aquaculture research.

III.2. Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

Please describe:

- the processes and criteria used in setting the national research priorities, including role of the participating organizations
- the processes and criteria used by the main aquaculture research organizations in setting their research priorities
- the mechanisms and methods that are used in coordinating research activities/programs of research institutions at national level

III.3. National Aquaculture Research Capacity

Please describe ***adequacy of national aquaculture research capacity***, highlighting following aspects:

- Existing research institutions and their research competence or specialization and annual budgetary support
- National aquaculture development priorities, priorities research needs, research facilities, and number and qualification of research personnel

III.4. Programs of Main Aquaculture Research Institutions

Please describe aquaculture research programs of the main aquaculture research institutions and their capacities, both facilities, personnel and budget.

III.5. Dissemination and Utilization of Research Outputs

Please explain the target users of the research outputs and methods used to transfer and disseminate the research results, including relationship between research and extension.

III.6. Issues and Needs in Planning and Implementing National Aquaculture Research Programs

Please describe issues, constraints and needs in formulating and implementing the national aquaculture research programs, by highlighting the following aspects:

- Institutional and management aspects
- Legal aspects
- Coordination and cooperation (between related institutions and programs)
- Information
- Human resources

- Research facilities
- Research environment
- Others.

IV. Observations and Discussions

Please interpret the information presented above, highlighting following aspects:

- Research Sector Priorities, in terms of requirements of the national aquaculture development plan and priorities
- Research competence and Programs of main aquaculture research organizations, in terms of ability to meet requirements of the national aquaculture development priorities and research priorities
- Capacities of aquaculture research organization, in terms of ability to meet requirements of the development priorities and research priorities
- Utilization of aquaculture research outputs, in terms of availability of research outputs to various target user groups in supporting their requirements and national development needs
- Processes and criteria used in setting aquaculture research priorities and formulating programs & projects, in terms of possible improvement
- Aquaculture research needs that are not addressed by existing aquaculture research programs and projects, indicating possible causes and suggesting ways to address them
- Issues, constraints and needs in formulating and implementing aquaculture research programs and projects, indicating how and who could initiate required actions
- Regional collaboration and cooperation in aquaculture research, in terms of potential research topics and mechanisms for future cooperation, including role of the existing regional and sub-regional bodies and programs.

V. Conclusions

Please summarize the key points discussed in the Section IV, including suggestions for ways and means to improve contribution of research to environmentally sound and socially equitable aquaculture development and recommendations for specific actions that could be implemented at the national and regional levels.

References

APPENDIX. List of On-Going Aquaculture Development and Research Projects

Title of Projects	Duration: From-To	Objectives	Target Beneficiaries	Implementing Agency/ies	Budget	
					Local*	External**

* - Local currency
** - US$

Annex 4. Summary of Aquaculture Development Priorities

Activities	BGD	CPR	DRK	HOK	IND	INS	IRA
Breeding & seed production		mass production of quality seed	supply of quality seeds, particularly of shellfish, echinoderm, crustaceans	supply of healthy seed	supply of quality seeds of carps, catfish, brackishwater & marine fishes, crustaceans, molluscs, bivalves	supply of quality seeds	seed production for Caspian sea fisheries (sturgeon, katum, bream, trout), shrimp, carp, perch
Culture sites, Identification & expansion		explore new sites		use of exposed waters		dev. & expansion of culture units	
Environmental management; biodiversity		water mgmt., pollution control	water quality & envemental mgmt.	water quality mgmt.; improved culture env.	env. monitoring	conservation & rehabilitation; sustainable use	sustainable use of resources
Feed and nutrition		feed & feed industry dev.		better & efficient feeds	feed formulation	feed development	
Genetic improvement		genetic improvement	genetic improvement		genetic improvement		
Health mangement		fish health mgmt.	fish health mgmt.	health mgmt.	health mgmt.		
Infrastructure & facilities development	infrastructure dev.		modernization of infrastructure & equipment		basic research facilities; design & construction of hatcheries, pen, cage, ponds, water recycling syst.	dev. of infrastructures & supporting facilities	dev. of infrastructures & supporting facilities
Inland waters & stock enhancement		resource enhancement	stock enhancement				stock enhancement
Integrated fish farming		paddy cum fish culture			agriculture-fish-horticulture-livestock		

Activities	BGD	CPR	DRK	HOK	IND	INS	IRA
Intensification of culture systems		pond culture; mariculture of high value species			carps, catfish, shrimp & prawn	brackishwater culture	
Legislation, regulations & policies		dev. & enforcement of legislation in aquatic pollution		improvement of regulatory control		regulation & monitoring of culture areas	
Marketing & market dev.	export market for shrimp	improvement of marketing					
Postharvest & product develop		products improvement			seaweed harvesting		
Socio-economic aspects	incentives for entrepreneur dev.	support for feed & processing industries			socio-economic evaluation of culture syst. & tech.	agribusiness development	
Species diversification		introduction of new species	introduction of superior species, coldwater species	alternative culture species		diversification	
Population dynamics, Stock assessment							
Technology transfer	extension service; training & HRD	extension			extension; training	provision of tech. services	extension, training
Culture & technology development	brackishwater culture; freshwater pond culture; shrimp	refinement of culture tech., particularly pond, mudflat & off shore shallow water cultures; tech. for new species	mariculture, particularly shellfish, echinoderm, crustaceans, oyster, abalone, seaweed; coldwater & mountain cultures	pond culture (carps, mullet, tilapia, catfishes, snakehead); mariculture (groupers, seabream, pango, seabass, amberjack, oyster)	crustaceans, oysters, molluscs, pearl mussel & oyster, mussels, seaweed, mullet, seabass, M tade, E suratensis, milkfish; carp, catfish, air-breathing fishes, shrimp, prawn, coldwater fishes; floodplain, lakes & reservoir & cage cultures	tech. for brackishwater, pond and marine finfish & shellfish culture; shrimp, tilapia, seaweed	sturgeon, katum, bream, perch, trout, carp, shrimp

Note: aq. = aquaculture; dev. = development; env. = environment; mgmt. = management; prod. = production; syst. = system(s); tech. = technologies

Activities	MAL	NEP	PAK	PHI	SRL	THA	VIE
Breeding & seed production	supply of quality seed	supply of quality seed		mass production of quality seeds; milkfish, shrimp, tilapia, carp, crab, seaweed	alternative seed production programs; broodstock dev. & mgmt.; carp	quality seed production; marine shrimp	quality seeds of shrimp, crustaceans, molluscs (oyster & pearl oysters halitosis, acra), seaweed, freshwater & marine fishes
Culture sites, Identification & expansion	new & nonconventional sites	exploration of potential areas	establish new farms for carp & trout		expansion of shrimp farm areas	mapping potential areas	
Environmental management, biodiversity	effluent treatment, zoning concept			waste mgmt. in shrimp culture; use of biodegradable substance for pest control & molluscs & seaweed as biofilter		pollution control; sustainable use; regulate no. of shrimp farms, use of drugs, chemicals & feeds	environmental mgmt.
Feed and nutrition	improved feeds			cost effective feeds	feed formulation		feed production
Genetic improvement	genetic improvement			milkfish, shrimp, carp, tilapia, seaweed		improvement	
Health mangement				health mgmt.	disease control	disease mgmt.,	disease control & prevention
Infrastructure & facilities development	farm mechanization		hatcheries & nurseries, support facilities	fish health laboratories	rehabilitation of seed prod. centres	rehabilitation of canals & rivers; seed prod. centres; seawater irrigation & waste water treatment	
Inland waters & stock enhancement	optimum utilization	utilization of large water bodies, ponds & wetland	optimum utilization & mgmt; stock replenishment	profiling & assessment for seven major lakes; mgmt. with concept of sustainable yield; carp; stocking	stocking reservoirs		
Integrated fish farming	agriculture-fish	paddy cum fish			fish-duck-chicken-rice		

Activities	MAL	NEP	PAK	PHI	SRL	THA	VIE
Intensification of culture systems				milkfish & shrimp culture			culture of crustaceans
Legislation, regulations and policies	dev. of aquaculture legislation; industrial aq. dev. areas planning			accreditation of hatcheries; integrated lake dev. & mgmt.	enforcement of regulations; zonal planning;	accreditation of hatcheries & farms; enforcement of env. standards & regulations	development & enforcement of policies & regulations
Marketing & market dev.			improvement of marketing channel			central market; cooperatives; control seed price	market dev.
Postharvest & product develop	improvement of postharvest handling		improvement of postharvest syst.				processing of seaweed; high value products
Socio-economic aspects		incentives for private sector	incentives for private sector	roll-over financing scheme	incentives for private sector	support soft loan project	
Species diversification	alternative culture species				diversification of culture species	new economic species	
Population dynamics , stock assessment				crab stock			
Technology transfer		demonstration & outreach; training of farmers & technicians	demonstrations, extension, tech. backup	extension, tech. services		extension & tech. support; data & information syst. for fishfarmers	extension
Culture & technology development	traditional practices with waste treatment syst.; new & refined culture tech & syst.; tech. for marine fish, oyster, crab, shrimp, ornamental fishes, molluscs	tech verification; polyculture of carp; pen & cage culture	modernization of tech.; carp, trout	milkfish, shrimp, tilapia, carp, seaweed, crab; environmentally sound tech.; tilapia-carp polyculture	diversification of culture syst.; carp, shrimp, crab, marine fishes, seaweed, molluscs; seasonal tank, coastal culture & seafarming	improvement of culture tech. & syst.	shrimp, crustaceans, molluscs (oyster & pearl oysters haliotis, acra), seaweed, finfish; cage culture

Note: aq. = aquaculture; dev. = development; env. = environment; mgmt. = management; prod. = production; syst. = system(s); tech. = technology/ies

Annex 5. Summary of Aquaculture Development Research Programme Priorities

Activities	BGD	CPR	DRK	HOK	IND	INS	IRA
Breeding & seed production	mass seed production; broodstock mgmt.; shrimp, catfish, seabass, mullet	mass scale seed production	seed production		broodstock mgmt. & breeding; hormone prod.; carp, catfish, shrimp, prawn, brackishwater fish, crustaceans, frog, molluscs, pearl oysters & mussels	quality seed production	sturgeon fishes, finfish, shrimp
Culture sites, Identification & expansion				env. assessment & culture in exposed water		inventory potential sites & strategies for expansion	
Environmental management and biodiversity	soil & water quality; effects of shrimp farms & estuarine ecology; biodiversity of Oxbow lake & floodplain; species conservation	genetic resources conservation	enhancement & rehabilitation of coastal breeding ground & stocks	reduction of self pollution	environmental monitoring	conservation & rehabilitation; genetic resource mangement; pollution & impacts of excessive culture	
feed and nutrition	cost effective feeds for carp, catfish & shrimp	feed & feed source dev.	fish nutrition & feed	improvement of feeds	fish nutrition & feed formulation; nutrients/organic waste recycling; food chain in ponds	organic & waste matter utilization	fish nutrition
Genetic improvement	collection, screening & evaluation of gemplasm; genetic improvement	germplasm improvement	seaweed		gene manipulation	inventory, evaluation & improvement	sturgeon, finfish
Health mangement	relationship between env. & disease epidemics	diagnosis, control & prevention		diagnosis, control & prevention	pathology, disease control & prevention	diagnosis, control & prevention	diagnosis, control & prevention
Aq. enclosure & engineering				cage design	design of pond, water recycling syst.		

Activities	BGD	CPR	DRK	HOK	IND	INS	IRA
Inland waters & stock enhancement	rehabilitation & stocking; assessment of aq. potentials; productivity mgmt.		assessment of aq. potentials; stock enhancement		optimum utilization	restocking	
Integrated fish farming	livestock-fish-crop				agri-fish-livestock,		
Intensification of culture systems	semi- & intensive culture practices		guidelines & methods		carp, catfish, shrimp, prawn		
Legislation, regulations & policies			environmental standards				
Postharvest & product develop	postharvest handling, e.g., hilsa & shrimp	processing & comprehensive utilization					
Socio-economic aspects	impacts of credit syst.				efficiency of culture systems; prod. economics		
Species diversification			new culture species	trial of new species			
Population dynamics, stock assessment	population of wide shrimp		population dynamics of lakes, reservoir species				
Culture systems & technology	pen culture; collection methods for wide shrimp fry; shrimp, finfish	tech. for full utilization of water bodies	tech. for coastal culture & mariculture	culture in exposed water	shrimp, prawn, brackshwater fish, crustaceans, molluscs, pearl mussels, oyster, pearl oyster, frog; cage & pen culture; sewage-fed farming	searanching	finfish (sturgeon, carp, kutum, bream, trout, pike/perch, aspius, barbus, roch) , shell fish (shrimp), seaweed; cage & pen culture, searanching

(Table continues) Note: aq. = aquaculture; dev. = development; env. = environment; mgmt. = management; prod. = production; syst. = system(s); tech. = technologies

Activities	MAL	NEP	PAK	PHI	SRL	THA	VIE
Breeding & seed production	economic marine species, indigenous freshwater fishes, shrimp, sea cucumber, crab, cephalopods, oyster	intensive nursing of fry & breeding of indigenous fishes; multiple breeding of carp; breeding of katle, sahar & asala	mahseer, shrimp	shrmp & crab, milkfish broodstock dev.; breeding of seaweed, milkfish, tilapia, catfish, carp, grouper, abalone macrobrachium, seabass, siganid, sea urchin, tridacna, pholas, placuna	freshwater prawn, marine fishes, ornamental fishes	fish breeding	mass prod. Of seeds; seabass, catfish, tilapia; preservation of gene pool
Culture sites, identification & expansion							
Environmental management; biodversity	effluent treatment; alternative use of shrimp ponds	water quality mgmt.		env. mgmt., particularly in shrimp culture	env. mgmt., e.g., in shrimp culture; wetland & mangrove mgmt.	environmental toxicology	conservation & sustainable use
Feed and nutrition	fish nutrition & feed formulation	fish nutrition & feed formulation		low-cost feeds & feed formulation for shrimp; crab, milkfish, tilapia, grouper, seabass, siganid, catfish		fish nutrition & feed development	
Genetic improvement		upgrading of IMC	improvement, particularly carp	seaweed, tilapia,		fish genetics	tilapia
Health management	diagnosis, control & prevention	control & prevention		control & prevention, particularly shrimp	control & prevention, particularly shrimp	disease mgmt.	disease mgmt.
Aq. enclosure & engineering	cage design						

Activities	MAL	NEP	PAK	PHI	SRL	THA	VIE
Inland waters & stock enhance, intensive use of		assessment of aq. potentials	stock replenishment; mahseer		community based mgmt.		
Integrated fish farming				crop rotation, milkfish	rice-fish		
Intensification of culture systems			carp, trout; farm mgmt.				
Legislation, regulations & policies				institutional policy studies; policies on use of inland waters	coastal zoning & planning		
Postharvest & product develop							processing tech.
Socio-economic aspects		impacts of river systems on population					
Species diversification	identification of suitable culture species						selection of suitable species; adopt foreign shrimp & fish species
Population dynamics, stock assessment			Islamabad area	seaweed stock assessment & mgmt	freshwater ornamental fish		
Culture systems & technology	tech. for open sea cage culture; commercially import. molluscs (oyster, abalone, cockles, etc.), shrimp; polyculture of shrimp-fish-seaweed-molluscs; recycling water syst.	trout in raceway, carps in cages, commercial production of trout	freshwater prawn culture, cage culture, culture in small dams & reservoirs; mahaseer	shrimp, crab, seaweed, tilapia culture; polyculture of milkfish; grow-out tech for seabass, grouper, siganid, pholas, placuna, sea urchin, abalone, tridacna; sustainable use of fishfarms	culture of shrimp/prawn, sea cucumber, crab, shellfish, ornamental fishes, finfish, seaweed, artemia; seafarming tech.	Tiger & freshwater prawn culture; brackishwater culture; freshwater culture; oyster, seaweed; culture systems	culture models for different ecosystems; culture of giant prawn & wetland fish; tech. for artemia production

Note: aq. = aquaculture; dev. = development; env. = environment; mgmt. = management; prod. = production; syst. = system(s); tech. = technologies

Section 2. Summary of the Survey Returns

Bangladesh

I. Background

Aquaculture is a traditional and age old practice in Bangladesh. Almost all the households possess a small- to medium-size dug out earth pond. In addition, most of the villages have relatively big size community ponds. Other types of culture systems used are pen and cage culture, paddy cum fish culture and culture-based fisheries in lakes and seasonal water bodies.

Aquaculture has been given importance in Bangladesh because of its potential for export earnings, generation of employment for the rural sector and its contribution to the supply of animal protein for the population. Bangladeshis are rice and fish eating people. Fish is an essential daily food item for the people and as such demand for fish is increasing with the increase of population. In the early sixties, the per capita annual fish consumption was 12 kg per person, which however has come down to 9.0 kg in spite of significant growth in the fisheries sector. Aquaculture sector is expected to contribute to the reduction in gap between demand and supply of fishery products. In addition to domestic demand, export market is equally important for the country to ease the balance of payment. Presently, high valued shrimp from coastal aquaculture is the main export earning commodity.

Key species cultured include catla, rohu, mrigala, kalbashu, other carps, catfishes, minnows, tilapia, prawn and shrimp, freshwater clam, mullet, and perches. Commonly used culture systems are pond, pen and cage culture in fresh- and brackishwaters, and paddy cum fish culture.

Aquaculture production in 1994-95 was 330,000 tons from 292,378 ha of production area, contributing 1.3% to the GNP. It was estimated that about 500,000 people are directly employed in the aquaculture sector.

II. National Aquaculture Development Plan

The Department of Fisheries, Ministry of Fisheries and Livestock is responsible for the development and implementation of the national aquaculture development plan.

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

Aquaculture development objectives	Aquaculture development priorities
• To increase fish production • To ensure availability of an adequate animal protein supply to the people • To generate foreign exchange earnings through export • To alleviate poverty through creation of job opportunities for the rural people	• Shrimp farming and brackishwater aquaculture • Inland freshwater pond aquaculture • Human resource development in the aquaculture sector • Strengthening of fisheries extension services • Infrastructure development for aquaculture and fisheries • Entrepreneur development in aquaculture • Export of aquaculture products, mainly shrimp

II. 2 Process followed in formulating the aquaculture development plans and priorities

In formulating national aquaculture development plans, the Department of Fisheries, MOFL follows consultative and participatory processes that seek the active involvement of the agencies and organizations in both public and private sectors, NGOs, research

organizations, and fish and shrimp farmers' associations. Main criteria used are sustainability and impacts on poverty alleviation.

II. 3 Implementation of the National Aquaculture Development Plans

Strategies for the implementation of the national aquaculture development plan are:

- Formulation and implementation of aquaculture development projects
- Extension and technology transfer

Action plans and objectives of the national aquaculture development plan

No information was provided.

Changes and emerging issues resulting from implementation of the aquaculture development plan

No information was provided.

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspect	• Poor coordination among related agencies and programmes	• Lack of coordination	• Improved interagency collaboration
Legal aspects	• Conflicts with other sectors, e.g., industry, water and land	• Overlapping of jurisdictions	• Interagency collaboration.
Information	• No established databases for aquaculture • Inadequate information exchange system • Weak extension	• Inefficient human resource development programme • Lack of facilities and manpower for extension	• Establishment of aquaculture databases • Strengthening information exchange systems • Development and implementation of extension projects • Assistance of regional organizations
Human resources	• Underutilization and non-utilization of skilled manpower	• Skilled manpower not placed at the right places	• Proper placement of manpower
Technical aspects	• Scarcity of quality fish feed • Lack of local feed ingredients	• Required feed factories have not yet been developed	• Lifting of ban on feed ingredient importation and reduction of tax
Physical and environmental aspects	• none		
Socio-economic aspects	• Availability of production credit:	• Complex procedures in obtaining credit and lack of collateral	• Changes in the credit system, i.e., simplified procedures and removal of collateral system

III. National Aquaculture Development Research

III. 1 Role, Objectives and Priorities of National Aquaculture Research

The key functions of the aquaculture research sector are to assist the government in planning, executing and implementing the national development plan for the sustainable development of fisheries resources and to provide technical support to entrepreneurs, farmers and other interested parties. The objectives of the aquaculture development research sector are:

- To increase fish production through generating improved aquaculture technologies.
- To undertake research (mainly applied and/or adaptive) for the development and optimum utilization of living aquatic resources.
- To evolve methods of import substitution and cost reduction, and improve processing of fishery products for domestic consumption and export purposes.
- To identify new production opportunities and develop them into usable levels.
- To develop skilled manpower in various fisheries disciplines and improve farmers' knowledge.
- To develop sustainable aquaculture technologies and fisheries management practices for both scientific exchange and extension purposes.
- To make arrangements for training and seminar-workshops (international and national levels) for planners, scientists, extension workers, entrepreneurs and farmers.

The Bangladesh Fisheries Research Institute (FRI) is the organization responsible for the planning and coordinating of the national aquaculture development research.

Aquaculture research priorities and action plans/programs for the year 1996-2000

All programmes are implemented by FRI and academic research institutions participate in implementation. The target beneficiaries of the programmes are fishfarmers and entrepreneurs.

Priority Research Areas	Research Programs	Expected outputs
Technology testing and packaging for country wide adoption	• All Bangladesh coordinated adaptive research project on fish culture and seed production in different agroclimatic & physiographic regions of the country • Pilot scale adaptive research for mass seed production of *M. rosenbergii* in backyard hatchery and its polyculture with fish • Pilot scale demonstration of fish culture in pens	• Dissemination of aquaculture technologies • Adequate supply of prawn seed • Suitable prawn-fish polyculture system
Stock improvement, productivity and management	• Collection, screening and evaluation of germplasm of important fish and their stock improvement and conservation of endangered species; intensive and semi-intensive culture practice for perennial and seasonal water bodies • Development of cost effective feeds for broodstock/fingerling of carps and catfish • Productivity enhancement and maintenance of soil and water quality in ponds • Relationship between environmental factors and fish disease epidemic • Productivity enhancement under integrated livestock-fish-crop farming system and to evolve suitable models of integrated farming systems • Credit system and its impact on fisheries sector: economic evaluation of credit programmes for freshwater aquaculture development	• Identification of strains and species of carp • Breeding and culture technologies of endangered species, genetic improvement of cultured species • Cost-effective feed • Baseline information on basic nutrients/elements in ponds, and on environmental factors in relation to fish diseases • Suitable models of integrated aquaculture farming • Information on sociodemographic characteristics of loan applicants

Priority Research Areas	Research Programs	Expected outputs
Broodstock management, mass seed production and culture of brackishwater shrimp and finfish; Estuarine ecology, biodiversity and monitoring of manmade changes	• Soil, water and productivity of gher fishery • Transportation of shrimp fry and their nursery management • Broodstock management and mass seed production of shrimp • Mono and polyculture of shrimp, prawn and fish • Development of shrimp diet from locally available ingredients • Population variation studies on wild stock of *P. monodon* and *M. rosenbergii* • Shrimp farming on mangrove and estuarine environment	• Improved fisheries management, including estuarine environment , coastal mangroves and ecological system • Improved collection and transportation techniques of shrimp fry • Culture technologies for mono and polyculture • Cost-efficient feeds
Productivity assessment, stock assessment, mariculture; product development, socio-economic assessment	• Breeding, seed production and culture of sea bass and mullet • Technology development for effective utilization of by-catches of shrimp trawling • Development of improved methods for handling, transportation and preservation of hilsa fish and shrimps • Catch monitoring, assessment of stock and productivity of marine fishery resources of Bangladesh • An economic study of production and marketing of small scale marine fisheries in Bangladesh	• Supply of live food for future aquaculture experiments and a bank of pure cultures of such organisms • Package of technologies for broodstock raising and management of seabass and mullet • Product development for bycatch/less attractive fish species with limited commercial value • Storage technologies for hilsa and shrimp • Information for development of industries for postharvest handling, and marketing • Comprehensive data on coastal fisheries development • Information on important stocks as well as on potential fishery development • economic analysis of small-scale marine fisheries, including marketing channels

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

Process	Criteria	Participants
• Consultative approach in identifying problems • Review of previous plans and research outputs • Formulation and screening of new plans • Approval of development plans	• National development needs • Government objectives • Recommendations of national workshops and scientists • Field-level problems • Available resources (funding, manpower and infrastructure)	• FRI, MOFL (Planning) • DOF and NGOs (identification of problems) • BARC (coordination) • Planning Commission (monitoring and evaluation) • Universities (research linkages)

III. 3 National Aquaculture Research Capacity

List of key aquaculture research organizations

Key aquaculture research organizations	Affiliation	Area of competence
Fisheries Research Institute	Ministry of Fisheries and Livestock	• Genetics and breeding • Seed production and culture of carp, catfish, shrimp and important indigenous endangered species • Nursery management of cultured species • Fish and shrimp nutrition • Disease and environmental pollution management • Pond productivity management • Integrated farming systems • Fisheries product development and quality control • Mariculture of important finfish, crustaceans, mussels • Fisheries economics
Bangladesh Agriculture University	Ministry of Education	• Basic research such as culture, nutrition, disease, and soil and water quality

Adequacy of research capacity in meeting the national aquaculture development needs

Priority research needs	Adequacy
Quality seed production; low cost feed development; pond productivity management; disease control	4*
Floodplain stocking; ecological characterization of floodplain; biodiversity maintenance and conservation methods; bio-dynamics of important fish and prawn species	4
Fish culture in irrigation and flood control project areas using pens	4
Mass production of prawn and shrimp juveniles	3
Water quality management in brackishwater aquaculture	3
Genetic improvement and conservation of fish resources	3
By-catch utilization, product development and quality control	2
Stock assessment of inland open water and marine fisheries resources	4

*On a scale of 1 to 5, 1 was least adequate, 5 was highly adequate

Number of research personnel by areas of specialization

Specialization	Ph. D.	M Sc.	B. Sc.	Res. Asst.	Total
Biological sciences	8	66		50	124
Physical and engineering sciences				17	17
Social science					
Economics		1			1
Legal specialists					
Others		5	50	87	142
Total	8	72	50	154	284

III. 4 Programs of the Key Aquaculture Research Institutions

List of the programs of the Fisheries Research Institute

Programmes	Objectives	Duration From/To
Productivity management of soil and water of ponds and floodplains	• To find out techniques of enhancing primary production for increased fish production	1990-
Stock assessment and management techniques of riverine fish	• To formulate improved management for inland freshwater fisheries development and improvement of the socio-economic conditions of fishermen	1996-
Stock and habitat improvement of commercially important fish species	• To protect the biodiversity of fish fauna and MSY of fish through high-yielding fish species	1995-
Brackishwater resource management, culture biodiversity, etc.	• To increase export earnings through increased shrimp production	1994-
Mariculture and stock assessment of marine fishery resources		1994-

III. 5 Dissemination and Utilization of Research Outputs

Target groups	Methods used to transfer research outputs
Policy planners	Research reports; Discussion and review meetings
Administrators and managers	Research reports; Discussion and review meetings
Fishfarming community	Extension materials; On-farm demonstration
Private sector and supporting industries	Training; Seminar-workshop
Research community	Information exchange (scientific reports)
Extension community	Training; Inter-institutional meetings
General public	Extension materials; mass media

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Development Research Programmes

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Limited authority • Inadequate inter-agency coordination		• Give research institutes broader autonomy • Strengthen inter-agency linkage
Legal aspects			
Information	• Lack of appropriate information exchange & sharing methods • Weak extension mechanisms	• Lack of data/information bases • No current information on scientific developments in all fisheries disciplines • Weak extension system	• Strengthen library and documentation centre of FRI • Improve linkage between research and extension • Strengthen exchange of information at regional and international levels
Human resources and research competence	• Insufficient skilled manpower	• Lack of expertise in planning and conducting multi-dimensional and disciplinary quality research	• Staff recruitment • Advanced training and development
Research facilities	• Inadequate infrastructure and laboratory facilities		• Improve and develop research facilities, particularly in marine and brackishwater stations
Research environment	• Low priority given to aquaculture research • Low level of funding		• Increase public and government awareness on importance of aquaculture research • Improve funding level

It was suggested that research priorities be given to:

- Fish/shrimp disease diagnostic service
- Fish nutrition and feed technology

- Aquatic pollution and its effects on fish
- Fish breeding and genetics.

IV. List of On-Going Projects of the Aquaculture Development Agency

Projects	Duration from/to	Target beneficiaries	Expected outputs	Participat'g organiz.	Budget
Second Aquaculture Development Project	1987-1996	Fishfarmers	• Stocking of floodplains • Extension of carp and shrimp technologies to farmers • Infrastructure development	DOF Commercial banks	138.28 Tkm US$ 38.31 (ADB)
Oxbow Lake fisheries and development management project	1988-1996	Fishermen	• Development of Oxbow Lake • Improvement of life of farmers near Oxbow Lake, involving them in lake management and catching of fish	DOF BARC	14.56 Tkm US$ 7.16 m (IFAD)
Third Fisheries project	1990-1996	Fishermen Fishfarmers	• Stocking of floodplains with fingerlings • Improvement of socio-economic conditions of fishermen • Extension of fish and shrimp culture technologies	DOF Water Development Board FRI	315.37 m US$ 92.3m (IDA) US$ 11.3 (ODA) US$ 4.45 (UNDP)
Aquaculture (under Project Mymensingh)	1993-2000	Fishfarmers	• Extension of pond aquaculture technologies • Financial assistance to farmers • Training for farmers	DOF Commercial banks NGOs	Tkm. 9.5 m US$ 3574.8 m (DANIDA)
Aquaculture projects in Patuakhali - Barguna	1994-2001	Fishermen Fishfarmers	• Extension of semi-intensive technologies • Development of model for effective fishing	DOF	Tkm. 9.36m US$ 5.8m (DANIDA)
Aquaculture extension in Bogna district	1995-1998	Farmers (marginal)	• Development of aquaculture in government ponds • Improvement of socio-economic conditions of marginal farmers	DOF	Tkm. 33.0 m
Carp and shrimp culture extension project in greater Nakhali	1994-2001	Fish farmers	• Extension of semi-intensive culture technologies on mixed shrimp-carp culture to farmers • Improvement of socio-economic condition of rural population	DOF Commercial banks NGO	Tkm 7.0 m US$ 9.3 m (DANIDA)
Thana-level aquaculture	1994-1999	Fishfarmers	• Development of sustainable aquaculture extension • Extension of pond technologies	DOF	Tkm 7.5 m

Projects	Duration from/to	Target beneficiaries	Expected outputs	Participat' g organiz.	Budget
Food-assisted aquaculture development project	1994-2000	Fishfarmers	• Development of waterbodies for fish culture • improvement of socio-economic conditions of rural population	DOF NGOs	Tkm. 20.0 m US$ 6.0 (EEC)
Shrimp landing and service centre	1994-1996	Shrimp farmers Sellers	• Improvement of quality of post-landing shrimp	DOF	Tkm. 95.0 m
Stocking fingerlings in open waters and floodplains	1994-2000		• Augmentation of fish production • Improvement of socio-economic conditions of farmers	DOF	Tkm. 288.5 m
Infrastructure development for shrimp farming in the private sector	1995-2000	Entrepreneurs Shrimp farmers Hatchery operators	• Production of shrimp seed • Employment of coastal population • Increase in fish production	DOF	Tkm. 590.2 m
Northwest aquaculture development project	1995-1999		• Extension of aquaculture technologies • Improve socio-economic conditions of landless and marginal population	DOF NGOs	Tkm. 27.5 m US$ 163.3 m (ODA)
Fishery training and extension	1991-1996	DOF staff NGOs Fishfarmers	• Human resource development in aquaculture and fisheries management	DOF	Tkm. 7.0 m US$ 1.9 m
Integrated fish culture in FAD/FCDI projects	1992-1997	Marginal farmers	• Fish culture in irrigated project areas • Involvement of marginal farmers in aquaculture	DOF DOL	Tkm. 117.6 m US$ 7.5 m
Fisheries research program development project	1995-1996		• Appropriate aquaculture technologies • Farm demonstrations	DOF	Tkm. 37.0 m
Integrated aquaculture (duckweed) project	1993-1997	Fishfarmers	• Duckweed-based aquaculture system • Extension of technology	DOF MOFL	TKM. 1.5 m US$ 1.6 m
Fisheries development in Kaplai lake	1995-2000	Fishermen	• Management system of Kaplai lake • Increased carp production in Kaplai lake	DOF	Tkm. 187.6 m
Marine Fisheries Academy	1994-1998	Technical personnel	• Manpower development in trawling industry	DOF	Tkm. 33.1 m
Shrimp culture project (completion)	1994-1996	Shrimp farmers	• Demonstration of technologies	DOF	Tkm. 110.0 m

V. List of On-going Projects of Main Aquaculture Research Organizations

Projects	Duration From/To	Target beneficiaries	Expected outputs	Participat'g organiz.	Budget
Fish breeding and genetics	1993-1998	Farmers Scientists	Increased fish production	FRI/ BAU/ DU	Tkm 1.272 m
Fish disease	1995-1998	Farmers Managers	Sustainable aquaculture	FRI/ BAU/ DU	Tkm 0.6 m
Fish nutrition	1993-1998	Farmers Feed industry		FRI/ BAU	Tkm 1 m
Breeding of Pangasius	1993-1998	Fishermen Farmers	Increased production	FRI/ BAU	Tkm 0.561 m
Effect of pesticide on fish	1993-1998	Managers Farmers	Baseline information	FRI/ DAE	Tkm 0.388 m
Improved extensive shrimp culture	1995-1998		Increased production	FRI/ BAU/ DOF	Tkm 0.9 m
Mariculture	1995-1998	Farmers Planners	MSY of marine resources	FRI/ MOFL / DOF	Tkm 0.9 m
Biological management of floodplain	1993-1998	Fishermen Farmers Managers	Increased fish production	FRI / DOF/ WB	Tkm 1.2 m US$ 0.073 m

VI. List of the Research Organizations Responding to this Survey

Fisheries Research Institute

China[1]

I. Background

China has a long history and tradition of aquaculture. Since 1980s, aquaculture has been considered by the government as an increasingly important sub-sector of agriculture that provides nutritional and economic benefits to the country with the world's largest and still growing population.

The current national aquaculture development plan is largely based on supply of fish food for domestic consumption and development of export market. Although a steady increase in total fishery production has made China the world's largest fish producer since 1990 (12.37 million mt), the average per capita consumption of fish food remains low, at about 11 kg per year. With the population expected to reach 1,300 million by the turn of the century, one of the key concerns of China is food security. Aquaculture is expected to contribute more to the national food security by increasing fish food production. At present, distribution of fish in terms of both production and consumption are not even within the country, i.e., availability of fish food in land-locked provinces and remote rural areas is low. Aquaculture development potentials in the inland provinces are considered to be high and efforts are being made to promote aquaculture in these areas.

In spite of a large production, China has a relatively small share of the world export market at present. To expand its share in the international market, China plans to strengthen and develop its capacity for culture of export oriented commodities. The guidelines for aquaculture and fisheries development and management take into consideration the rational use of resources, and aim to improve the quality of fishery products.

In 1994, aquaculture production in China was 11,350,000 tons from a production area of 5,102,510 ha. Aquaculture contributed 1.07% to GNP (equivalent to 55.9 billion Yuan) and directly employed 2,661,344 people during the year.

II. National Aquaculture Development Plan

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

Aquaculture Development Objectives	Aquaculture Development Priorities
To increase fish production	• To improve productivity of aquaculture farms through (a) improvement of existing culture technology; (b) up-grade farmers skills; and (c) genetic improvement of cultured species, (d) improved water management and disease prevention capability • To explore new sites (unutilized land or water bodies) for aquaculture • To promote fish culture in paddy fields • To strengthen aquaculture supporting industry (feeds, processing)
To conserve and enhance resources for culture-based capture fisheries	• To formulate fishery legislation & regulations on a scientific basis • To enhance resources by releasing hatchery-produced seeds
To increase production of high-quality or high-value species	• To introduce new species for culture • To develop or refine the techniques for the culture of new species (hatchery techniques, feeds and feeding, grow-out culture)

(Table continues)

[1] The gaps in the survey responses (there was no response from the agency that is responsible for planning and coordination of the national aquaculture development research) were supplemented by information provided by the NACA staff, Dr. Chen Jiaxin, Director of the Freshwater Fishery Research Centre in Wuxi and Ms. Sun Yan, the representative of China to the Regional Workshop on Aquaculture Development Research Priorities and Capacities in Asia, held in Bangkok Thailand on 21-23 May 1997.

Aquaculture Development Objectives	Aquaculture Development Priorities
To protect fisheries and aquaculture	• To develop and enforce legislation and regulations in the areas of water pollution control
To restore coastal shrimp farming	• To improve water quality standards and water management skills of farmers • To develop measures to control shrimp disease problems

II. 2 Process followed in formulating the aquaculture development plans and priorities

Processes	Criteria	Participants
Consultation at national, provincial, municipal levels	National development priorities	• Bureau of Fisheries at the national, provincial and municipal levels • Research institutions and Universities • Extension agencies and departments at the national, provincial, municipal, county and town levels

II. 3 Implementation of the National Aquaculture Development Plans

The strategies towards the implementation of the national aquaculture development plan take into account the simultaneous development of aquaculture, fishing and processing, with emphasis on one or the other depending on local conditions. The strategies currently adopted include:

- Extension of intensive inland pond culture technology in the regions where aquaculture is less developed
- Development of culture-based fisheries and fishery resource enhancement in medium- large inland open waters (lakes, canals, reservoirs, etc.)
- Development of coastal aquaculture, particularly coastal pond culture, culture on mud flats and in off-shore shallow water; and intensive culture of high value marine species
- Genetic restoration or improvement of popular, commonly cultured species
- Development of feeds and the feed industry
- Strengthening capacities for management and prevention of aquaculture diseases
- Improvement of postharvest handling and processing technologies

Action plans and objectives of the national aquaculture development plan

No information was provided.

Changes and emerging issues resulting from implementation of the aquaculture development plan

Action plans	Changes resulting from actions	Emerging issues	New actions introduced
Mass seed production and larval rearing	Improved production		
Disease control and health management	Increased outputs & economic benefits		
Improvement of aquaculture production facilities	same as above	Lack of funds	
Propagation	same as above		
Environmental protection	Aquaculture sustainability	Need for more extension	

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspects	• Gaps (weak linkages) between research, extension and production • Inadequate support given to aquaculture • Lack of enforcement of environmental law		
Legal aspects	• Lack of regulations on siting and management		
Information	• Ineffective technology transfer		
Human resources	• Lack of skilled farm workers		
Technical aspects	• Technology for disease control, breeding and seed production,		
Physical and environment aspects	• Pollution and other environmental factors affecting aquaculture		
Socio-economic aspects	• Inadequate supporting industries		

III. National Aquaculture Development Research

III. 1 Objectives and Priorities of the National Aquaculture Research (from the presentation at the workshop on 21-23 May 1997)

- Breeding technologies and mass seed production of target species
- Gemplasm improvement and genetic resource conservation
- Fish disease control and prevention, and health management
- Technologies for full utilization of water resources
- Fish nutrition and feed development, including feed sources
- Postharvest process and comprehensive utilization of aquaculture products

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

No information was provided.

III. 3 National Aquaculture Research Capacity

China is a country with a long history of aquaculture. Along with the rapid development of the aquaculture industry, a rather complete aquaculture research system has been established through nearly a half-century of efforts of government. The system is large, comprising national research institutions under the Chinese Academy of Fishery Sciences, fisheries universities and colleges and provincial research institutions. The Chinese aquaculture research system maintains 5,000-6,000 scientific professionals. Some of the research institutions are equipped with advanced equipment and facilities. Generally, the Chinese aquaculture research system is capable of undertaking all aspects of aquaculture research. The aquaculture research system has made significant contributions to the increase in national aquaculture production. Chinese researchers are undertaking advanced research, even leading roles, in many aspects of aquaculture research. However, due to the constraints such as inadequate funding, lack of nation-wide coordination and difficulties in management mechanisms, the potential of the Chinese aquaculture research system has not been fully developed.

List of key aquaculture research organizations

1. Organizations under the Chinese Academy of Fisheries Sciences, Ministry of Agriculture

    - Yellow Sea Fisheries Institute
    - East China Sea Fisheries Institute
    - South China Sea Fisheries Institute
    - Pearl River Fisheries Institute
    - Yangtze River Fisheries Institute
    - Heilongjiang Fisheries Institute
    - Freshwater Fisheries Research Institute
    - Freshwater Fishery Research Centre, Wuxi
    - Fisheries Machinery & Instrument Research Institute
    - Fisheries Engineering Research Institute
    - Fisheries Economics Institute

2. Organizations Under the Chinese Academy of Science

    - Hydrobiology Institute
    - Qingdao Oceanology Institute
    - South China Sea Oceanology Institute

3. Key Universities and Colleges

    - Shanghai Fisheries University
    - Dalian Fisheries College
    - Zhejiang Fisheries College
    - Xiamen Fisheries College
    - Zanjiang Fisheries College

4. Organization under the Ministry of Water and Hydro-Power

    - Reservoir Fisheries Institute

III. 4 Programs of the Key Aquaculture Research Institutions

The three research organizations (see item VI) responding to the survey indicated that the objectives of their research programmes are:

- To advance the fishery scientific knowledge and offer practical aquaculture service for the country.
- To set up basic theory and research technological methods of aquaculture towards the solution of problems in practical aquaculture production.
- To resolve key problems in basic and applied fields which obstruct mariculture development if China.
- To extend and apply new and advanced technology towards increasing mariculture production.
- To carry out basic and applied research on freshwater fisheries.

The above objectives would be in most respects similar to those of the other institutions under the CAFS, differing only in some special areas or commodity orientation.

List of the research programmes of the three aquaculture research organizations

Priority research areas	Objectives	Duration From/To
Biotechnology of fisheries	To develop fish growth hormones and study fish gene transfer	1995
Biotechnology of marine algae	To develop alga with high-quality colloids and good growth	2000 ?
Carrying capacity of culture sites	To determine the carrying capacity of culture sites	1993-
Cloning of fish interferon gene	To study cloning of fish interferon gene	2000 ?
Domestic artemia resources	To provide quality artemia	2000 ?
Fish disease and control	To study fish diseases and their prevention	1995
Fish disease: Studies on epidemics in high-value commercial fish	To develop practical preventive measures to epizootics	2000 ?
Fish diseases: Detection techniques of shrimp disease	To establish the pathogen-detecting technology, diagnosis technology, care and prevention of disease	1996
Fish germplasm resources	To preserve fish germplasm resources in laboratories and ecological bank	1995
Fishery resources and environments	To study fisheries resources and environmental problems	
Genetic breeding	To develop fast-growing and disease-resistant species	1996-
Mariculture ecology	To optimize the culture models	1996-
Special species in aquaculture	To conduct artificial culture and propagation of Chinese turtle	1995

Number of research personnel of the three research organizations by area of specialization

Specialization	Ph D.	M Sc.	B Sc.	Res. Assist.	Total
Biological sciences	45	53	84	44	226
Physical and engineering sciences	12	8	20	32	72
Social sciences					
Economics					
Legal studies					
Other					
Total	57	61	104	76	298

III. 5 Dissemination and Utilization of Research Outputs

The three research organizations indicated that their research outputs are disseminated through direct contacts with clients; technical supervision or guidance (provided to farmers); or training courses.

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Lack of coordination among related institutions and programmes • Inadequate support and inputs to research	• Lack of funds for research • Exchange channels are impeded	
Legal aspects			
Information	• Lack of mechanisms for disseminating research outputs • Inadequate information exchange system and information exchange • Weak technology transfer	• Insufficient methods and efforts in information dissemination • Lack of technical documents in English	• Strengthen extension and information dissemination capacity • Improve communication linkages, e.g., internet
Human resources and research competence	• Lack of skilled researchers	• Lack of training opportunities	• Provide training for research staff
Research facilities	• Lack of a high-standard laboratory and outdated facilities • Lack of research materials (e.g., artemia)	• Difficulty in obtaining funds	• Identify or generate funding sources • Provide more funds for research materials

Category	Issues	Constraints	Required Actions
Research environment	• Lack of research budgets • Poor linkage between basic research and applied or field-oriented research • Poor linkage between research sector and production sector • Difficulties in balancing direct economic benefits and long-term social benefits • Outdated research approaches • Lack of international cooperation	• Limited funds for research	• Increase budget for research programs • Improve and strengthen coordination among related institutions and sectors • Enhance international cooperation

Other suggestions:

- Faster transfer of scientific research results
- Improve the effectiveness and efficiency of aquaculture research
- Collaboration with scientists on the national and international levels (1) to pave the way for bigger research programs and (2) attract younger scientists.
- Establish an information system on crustacean culture techniques in the Asia-Pacific; and establish a system of communication with those involved in artemia resources development in the USA
- Establish regional and national specimen, pathogen and gene pools.

IV. List of On-Going Projects of the Aquaculture development agency

Projects	Duration From/To	Expected outputs	Implementing organizations	Budget
Shrimp disease control	1996-1997	Improved yield	Luan Nan Fisheries Bureau FAO	US$ 0.245m[2]
	1997	Improved yield	Coastal provincial fisheries bureaus World Bank	US$ 45.0m
	1995	Improved yield	Ministry of Agriculture Coastal provincial fisheries bureau	Yuan 30.0m
Aquaculture development program	1997-2000	Increased output	ADB Fisheries bureau (Liaoning, Shandong, Hebei, Dalian and Qingdao)	US$ 70.0m
	1997	Increased output	World Bank Coastal provincial fisheries bureau	US$ 65.0m
	1999-2003	Increased output	Japanese govt. Fisheries bureau (along the Yellow River area)	US$ 54.0m
	1997	Increased output	Korean govt. Some Provincial fisheries bureaus	US$ 10.0m
Introduction of seed	1997	Increased output	Australian govt. Some provincial fisheries bureaus	US$ 4.97m
Fish and crab culture in paddy fields	1993-2000	Increased output	Ministry of Agriculture Fisheries bureaus in Jiangsu, Chongging, Sechuan, Hubei and Yunnan	Yuan 10.0m/ yr
Small cage culture	1992-2000	Increased output	Ministry of Agriculture Fisheries bureaus in Shanxi, Henan, Gai su, Neimeng, Ningxia, Chongging	Yuan 10.0m / yr.
White bait propagation	1993-2000	Increased output	Ministry of Agriculture Fisheries bureaus in Heilongjiang, Yunan, Qinghai, Jilin, Xinjiang, Guizhou, Beijing Freshwater Fisheries Research Institute	

[2] m = million

V. List of On-going projects of the three Aquaculture research organizations

Projects	Duration From/To	Expected outputs	Participating organiz.	Budget (Yuan)
Biotechnology of algae	1993-96	High quality algae	SFU	0.060m
Fish genetics resource	1991-96	Fish genetic pool	SFU	0.050m
Comprehensive inland aquaculture	1991-96	Increased fish production	SFU	0.030m
Studies on shrimp health	1991-96	Effective control of epidemics	SFU	0.150m
Black carp nutrition	1991-96	Knowledge on black carp nutrition	SFU	0.100m
Phyco-ecology and bioenergetics of several fish species	1991-96	Knowledge on energy metabolism of several fish species	SFU	0.070m
Domestic artemia resources	1996-00	High quality artemia	SFU	0.200m
Evaluation of generically improved tilapia in Asia	1995-96	Knowledge on the genetic character of tilapia	SFU	0.050m
Yangtze River carp genetic diversity	1994-95	Knowledge on the genetic character of carp	SFU	0.050m
Selection of herbivorous carp	1986-95	High quality herbivorous carp	SFU	0.06m
Larvae development of blood clam	1994-98	Knowledge on the biological features of larvae development	YSFRI	0.1m
Large scale mariculture in Bohai Sea	1996-00	Increased output	YSFRI	1.0m
Carrying capacity in bay system	1996-00	Optimal culture models	YSFRI	1.0m
Triploidy of scallop	1996-00	Breeding of seedlings; culture technology	YSFRI	1.0m
Fish culture	1996-00	Culture of marine fish in cage or indoor tanks	YSFRI	0.50m
Ecological culture of prawn	1996-00	Lower production costs; increased profit	YSFRI	0.50m
Classification of HHNBS	1996-98	Identification of new virus, HHNBS	YSFRI	0.090m
Control of disease epidemics of shrimp	1993-95	Determination of the pathogen and establishment of diagnosis technology, transmission routes and control	YSFRI	0.350m
Carrying capacity of Sanggoa Bay	1993-96	Optimal culture models	YSFRI	O.30m US$0.030 m
Sino-USA Marine Living Research Cooperation Panel Program		Knowledge on *SPF P. chinensis*	YSFRI Univ. of Arizona	
Fish germplasm resources	1991-00	Better fish species for culture	YRIF Sponsor	0.70m US$ 0.020m
Fish biotechnology	1995-98	Methods of biotechnology in aquaculture	YRIF FAO	0.30m US$ 0.01m
Fish disease and control	1995-00	Control of fish disease	YRIF	0.30m
Fish nutrition	1995-98	Improved fish feed	YRIF	0.20m
Fishery resources and environment	1995-00	Conservation of fishery resources	YRIF	0.50m
Aquaculture techniques	1995-00	Increased fish production	YRIF	0.20m
Special species of aquaculture	1995-00	Culture techniques of the Chinese turtle	YRIF	1.0m
Study of labeling techniques by remote sensing on Chinese sturgeon	1995-98	Fish resources conservation	YRIF	US$ 0.2m
Comparison of species quality of farmed and wild silver carp by molecular biology method	1994-96	Selection of improved fish	YSFRI FAO	US 0.01m

VI. List of the Research Organizations Responding to this Survey

1. Yangtze River Institute of Fisheries (YRIF)
2. Yellow Sea Fisheries Research Institute (YSFRI)
3. Shanghai Fisheries University (SFU)

Democratic People's Republic of Korea

I. Background

Fisheries plays an important role in national economy and well-being of the people. The national fisheries policy gives importance to aquaculture, and investment to aquaculture has been increased. Total aquaculture production in 1995 was estimated at 700,000 tons from 64,000 ha.

II. National Aquaculture Development Plan

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

The Aquaculture Department of the Ministry of Fisheries is responsible for formulating and implementing the national aquaculture development plans.

Aquaculture Development Objectives	Priority Areas
Seed production (shellfish, echinoderms, crustaceans)	• Breeding technology • Improved rate of spawning and fertilization • Technology for water and environmental management
Introduction of mariculture technology	• Technology for oyster, abalone and shellfish culture
Modernization of culture facilities	• Modernization of hatcheries • Improvement of aquaculture equipment • Improved water monitoring methods, including remote monitoring
Stock enhancement through intensive release of fish seed	• Hatchery construction & increased production of seed • Stock enhancement
Introduction of culture species with short production cycle and high productivity	• Identification, research on suitable native species • Introduction of superior foreign species
Culture of cold water species and mountain aquaculture	• Identification, research on appropriate cold water species, e.g., trout

II. 2 Processes followed in formulating the aquaculture development plans and priorities

No information was provided.

II. 3 Implementation of the National Aquaculture Development Plan

Action plans	Resulting Changes	Issues	Required Actions
Seed production of shellfish, echinoderm, crustacean	• Industrialization and automation of seed production • Secure seed supply	• Need to introduce modern science and technology for seed production	• International cooperation and assistance in training and information exchange, particularly with NACA
Introduction of culture technologies for three important species	• Availability of new productive species for culture	• Lack of culture technology for three important marine species	• Training and study tours through NACA program
Improvement of culture facilities and modernization of mariculture	• Modernization of culture facilities • Implementation of environmental monitoring methods	• none	• none

(Table continues)

Action plans	Resulting Changes	Issues	Required Actions
Introduction of new fish species	• Introduction of productive species that require less strict feeds and feeding • Introduction of cold fresh water species	• Lack of information on the species that can be fed on a variety of feeds and cold fresh water species	• Cooperation with NACA
Intensive production and release of fry	• Guaranteed & increased seed production		• Access to technology

II. 4 Issues and needs in formulating and implementing national aquaculture development plans

Category	Issues	Constraints	Actions required
Administrative and institutional aspects	• none		
Legal	• none		
Information	• Difficulty in obtaining technical documents		• Assistance in cooperation with other organizations and obtaining technical information • Assistance from NACA
Technical Aspects	• Lack of technical documents and aquaculture guidelines in all aspects		• Assistance from NACA
Human resources	• none		• Training (in-country and overseas)
Physical Environment	• none		
Socio-economic Aspects	• none		
Others	• none		

It was noted that DPRK has no critical issues or problems in aquaculture development.

III. Aquaculture Development Research

III. 1 Objectives and Priorities of aquaculture development research

The functions of research sector are to provide scientific and technical support and guidance in support of the national fisheries policies. The overall aquaculture research objective is to develop technology for seed production and mariculture. Specific objectives are:

- to improve skills of technical staff
- to increase understanding of biology of the target species
- to develop culture technologies, including technologies for seed and feed production
- to improve quality and quantity of seeds
- to improve management standards for seed production

Priority Research Areas	Research programs	Duration From/To	Implementing Organisation	Budget (N. Korean Won)
Seaweeds	• Production of quality, both taste and nutritional contents, sea weeds • Development of new strain that is resistant or tolerant of warm/high water temperature	1998- 1996-	East Seaside Aquaculture Institute	60,000 40,000
Breeding & hatchery technologies for three target species	• Research on genetics • Identification and mass production of natural organisms to feed larvae of the cultivated species • Research on breeding and production	1996- 1998- 1996-	West Seaside aquaculture Institute	140,000 60,000
Coastal aquaculture	• Improvement of natural habitats and breeding grounds for fries and seeds • Identification of suitable culture species • Research on breeding & stock enhancement	1996- 1996- 1998-	East/West Seaside Aquaculture Institute	50,000 100,000 100,000
Mariculture	• Research on improved culture technology for three target species • Technologies for intensive culture	1996- 1998-	East/West Seaside Aquaculture Institute	100,000 100,000
Inland aquaculture	• Assessment of aquaculture potentials of inland waters • Biology and population dynamics of target species in lakes and reservoirs	1996-	Fish Farming Institute	90,000 60,000
Intensification of aquaculture	• Research on biology of target species • Standards for water management	1996- 1996-	Fish Farming Institute	40,000 60,000

III. 2 Processes and criteria used in formulating aquaculture development research plan and priorities.

The Korea Academy of Fisheries under the Korea State Academy is responsible for planning and coordinating national aquaculture development research programs.

III. 3 National Aquaculture Research Capacity

Aquaculture research organisations and their programme competence

Name of research institution	Affiliation	Programme competence
Korea Academy of Fisheries	Korea State Academy	Co-ordination of aquaculture research; Dissemination of research outputs; Technical exchange with international organisations
East Coast Aquaculture Institute	Korea State Academy	All aspects of coastal aquaculture and resource conservation
West Coast Aquaculture Institute	Korea State Academy	All aspects of coastal aquaculture and resource conservation
Fish Farming Institute	Korea State Academy	All aspects of fishfarming

National Aquaculture Research Capacity

Aquaculture Development Priority	Priority Research Needs	Adequacy of Research		
		Facil.	No. staff	Skills
Seed production for three target species (shellfish, echinoderms and crustaceans)	Technology for breeding and genetic research	4	4	4
	Modernization of breeding facilities	3	4	4
	Prevention and control of diseases and improved hatchery management	2	4	3
Culture technology for three target species	Cell biology and genetics	3	4	4
	Improved production technology	3	4	2
Modernization of mariculture facilities	Modernization of hatchery facilities and standardization of hatchery management methods	3	4	3
	Implementation of environmental monitoring	2	4	4
Promotion of species that require less strict feeds and are cold water tolerant	Selection and introduction of species that require less strict feeds and feeding	3	3	3
	Select and introduce species suitable for cold water	4	4	3
Secure seed supply, both in quantity and quality	Improved quality and quantity of hatchery facilities	3	4	4
	Industrialization of seed production	2	4	3

Note: 1 - no capacity; 2 - inadequate; 3 - adequate; 4 - good; 5 - excellent

III. 4 Programmes of Aquaculture Research Organisations

No information was provided.

III. 5 Dissemination and Utilisation of Research Outputs

Target groups	Main Dissemination Methods
Policy planners	Reports
Administrator, managers and agency	Reports
Fishfarming community	Technical manuals, guidelines
Private sector and supporting industries	Reports and analysis of data
Research community	Technical documents
Extension Community	
Public at large	

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research Programs

Category	Issues	Constraints	Actions Needed
Administrative and institutional aspects	• none	• none	• none
Legal aspects	• none	• none	• none
Information	• Inadequate information exchange and sharing	• Lack of efforts to contact regional and international programs and services	• Closer co-operation with NACA
Category	**Issues**	**Constraints**	**Actions Needed**
Human resources & research competence	• Shortage of physiological experts		• In-country and international training • Participation in regional programs, e.g. NACA
Research facilities	• Lack of special equipment, e.g., electron microscope	• Insufficient funds	• More national and international supports
Research environment	• none	• none	• none

IV. List of Ongoing Projects of Aquaculture Development Agency

No information was provided.

V. List of Ongoing Projects of Aquaculture Research Organizations

No information was provided.

VI. List of Research Organizations Responding to the Survey.

None

Hong Kong China

I. Background

Aquaculture in Hong Kong contributes significantly towards meeting domestic demand for live fish. In 1995, pond fish culture production represented about 11 percent of consumption of freshwater fish while marine fish culture contributed 20 percent of total marine live fish consumption.

The 1995 aquaculture statistics shows that production from aquaculture was 8270 mt from a total production area of 1398 hectares. (This does not include area under oyster culture.) Production was valued at HK$ 298 million. The sector also directly employs 6350 people. In 1993, the contribution of aquaculture and the fishery sector to GDP was 0.2%.

II. National Aquaculture Development Plan

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

Aquaculture Development Objectives	Aquaculture Development Priorities
• To increase productivity	• Water quality management • Fish health management • Improvement of culture environment • Better and more efficient feed • Supply of healthy fry
• To find new culture sites	• Culture in exposed waters
• To reduce market competition	• Alternative species for culture

II. 2 Process followed in formulating the aquaculture development plans and priorities

Processes	Criteria	Participants
• Consultative process • Local initiatives (fishfarmers report problems)	• Importance of the problem/issue • Availability of expertise and resources • Farmers' needs	• AFD staff (sets priorities and action plans; implements plans) • Fishfarmers (reports problems and areas for development, collaborates in field trials, provides feedback) • Other government departments (interaction with other issues, provides assistance) • Environmentalists (offers observations and criticisms on environmental impact) • Tertiary institutes (academic and applied research)

The Agriculture and Fisheries Department (AFD) is the agency responsible for the formulation and implementation of the national aquaculture development plan.

II. 3 Implementation of the National Aquaculture Development Plans

Main cultured species

Species	Common Name	Production (tonnes)	Value (US$ x1000s)	Culture System
Fresh water pond fish culture				
Channa maculatus	Snakehead	310	1,133	Pond,
Clarias fuscus	Catfish	120	342	monoculture
Lates calcarifer	Sea bass	-	-	Pond,
Ctenopharyngodon idella	Grass carp	860	1,433	monoculture
Hypophthalmichthys nobilis	Bighead carp	1,220	2,080	-
Hypophthalmichthys molitrix	Silver carp	490	471	Pond, polyculture
Cyprinus carpio	Common carp	920	1,427	Pond, polyculture
Carassius auratus	Edible goldfish	-	-	Pond, polyculture
Mugil cephalus	Grey mullet	605	1,606	Pond, polyculture
Oreochromis niloticus/ mossambicus	Tilapia	1,195	1,195	Pond, polyculture
				Pond, polyculture
				Pond, polyculture
Marine fish culture				
Epinephelus tauvina	Green grouper	199	2,190	Floating netcages
Epinephelus areolatus	Spotted grouper	500	4,237	Floating netcages
Epinephelus akaara	Red grouper	166	2,266	Floating netcages
Mylio latus	Yellow finned	130	1,541	Floating netcages
Rhabdosargus sarba	seabream	830	5,091	Floating netcages
Chrysophrys major	Goldlined seabream	80	539	Floating netcages
Lutjanus russelli	Red pargo	227	1,874	Floating netcages
Lates calcarifer	Russels snapper	324	2,876	Floating netcages
Seriola purpurascens	Seabass	167	1,207	Floating netcages
	Amberjack			
Oyster culture				
Crassostrea gigas	Oyster	805	811	Bottom/raft culture

Action plans and objectives of the national aquaculture development plan

Action plans	Objectives	Target beneficiaries	Expected results
Improvement of culture conditions	• To increase water circulation • To reduce raft density • To reduce self-pollution	• Fishfarmers • Administrators	• Improved culture conditions
Development and extension of better feed	• To reduce self-pollution • To provide balanced diet • To increase feed efficiency	• Fishfarmers • Administrators	• Improved feed for major cultured species
Fish disease and fish health management	• To diagnose disease • To find preventive and control measures	• Fishfarmers • Extension staff	• Reduced disease outbreak
Fish culture in exposed waters	• To find new culture sites • To improve conditions in sheltered fish culture zones	• Fishfarmers • Administrators	• Better fish culture environment
Alternative species for culture (note: this is yet in the planning stage)	• To reduce market competition • Possibly undertake integrated farming to improve environment	• Fishfarmers	• Better productivity • Better returns

Changes and emerging issues resulting from implementation of the aquaculture development plan

Action plans	Changes or effects	Issues	Actions required
Improvement of culture conditions	Significant improvement of culture conditions in the expanded zones	• Mariculturists' demand to expand to other zones	• Set criteria for zone expansion to avoid conflicts with other users
Development and extension of better feed	Adoption by fishfarmers of moist pellet feed	• Problems with transportation and delivery (fishfarmers try to make it themselves)	• Assist and facilitate local manufacture of pellet machine • Secure supply of good quality feed ingredients • Extension of the importance of fish meal quality
Fish disease and fish health management	Positive response of fishfarmers to need for reports on fish disease incidence for proper diagnosis	• Lack of ready cure for diseases • Non-reporting of diseases after disappointment due to lack of ready cure	• Active monitoring of fish disease situation
Fish culture in exposed waters	Cage culture in exposed waters found technically feasible (leads to faster growth of fish)	• Poaching problem	• Ensure security • Increase operational size to as to economize on security costs

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspects	• Lack of support for aquaculture	• Bad image of aquaculture (portrayed by environmentalists as "serious polluter")	• Promotion of environmentally sound practices & increase public awareness on such practices
Legal aspects	• Overlapping jurisdiction	• Aquaculture zone and its control given to AFD and water quality standards to another department (EID)	• Negotiation re water quality standards • Press for mixing zone concept
Information	• Lack of appropriate information delivery methods and mechanisms	• Reluctance of fishfarmers to attend seminars, training classes, etc.	• Farm visits • On-site demonstrations • Farm trials in collaboration with progressive farmers
Human resources	• Lack of skilled personnel in fish disease diagnosis	• Lack of training and expertise particularly for marine finfish disease	• Appropriate training in suitable institutions (assistance from NACA needed)
Technical aspects	• Lack of guidelines on fish disease treatment and prevention	• Lack of research support in this area	• Assistance from NACA-OIE program
Physical and environment aspects	• Shortage of suitable sites for aquaculture • Pollution	• Limited land and water space	• Improvement of existing sites • Explore possibility of cage culture in exposed waters • Measures to reduce pollution
Socio-economic aspects	• Low market price	• Markets flooded with imports	• Culture a variety of species to avoid market competition

The **supply of healthy fish fry** is a **critical aquaculture development need** that is not addressed by the existing aquaculture development programs and projects. It is considered uneconomical to establish hatcheries in Hong Kong. A possible course of action is to ensure adequate supply of fish fry from neighboring countries - Taiwan, Thailand, China - at reasonable price.

III. National Aquaculture Development Research

III. 1 Role, Objectives and Priorities of the National Aquaculture Research

The agency responsible for planning and coordinating the national aquaculture development research sector is the Agriculture and Fisheries Department (AFD), Hong Kong Government.

The main objectives of the national aquaculture research sector is the planning and coordination of aquaculture research, particularly by;

- Conducting research on technical problems and providing solutions/measures to alleviate situation.
- Conducting adaptive studies on technological methods for introduction to local farmers.

The role of the public research organizations is to promote and facilitate aquaculture production (on the part of the government); and on the part of tertiary institutions, to conduct academic research on specific issues and undertake collaborative studies with AFD.

In supporting national aquaculture development, the research programmes of AFD give priorities to such areas as feed development, fish health management, cage design, environmental management and culture trial of new culture species.

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

Type of organization	Process	Criteria	Participants
National aquaculture research coordinating body	• Local initiatives (farmers' reports) • Consultative process (identification of issues and problems by AFD)	• Assessment of the importance of the problem/issue • Availability of expertise and resources • Farmers' needs	• AFD staff • Fishfarmers • Government sector (other departments • Pressure groups • Tertiary institutes
Research organizations	• Grant proposal	• Scientific merit • Research expertise	• Research supervisor • Student • Professors

Note: The process followed by the national aquaculture research sector is the same as that followed by the national aquaculture development agency.

III. 3 National Aquaculture Research Capacity

List of key aquaculture research organizations

Key aquaculture research organizations	Institutional affiliation	Areas of competence
AFD	Government	All aspects of aquaculture
Hong Kong Chinese University	Autonomous	Physiology, Culture
Hong Kong Baptist University	Autonomous	Feed; Environment
Hong Kong City University	Autonomous	Feed; Ecotoxicology
Hong Kong Polytechnic University	Autonomous	Feed, Mangrove ecology
University of Hong Kong	Autonomous	Physiology; Endocrinology; Molecular biology of cultured species, Environmental pollution, Water quality modeling
Hong Kong University of Science and Technology	Autonomous	Culture of algae; Integrated culture, Molecular biology of shrimp, Phytoplankton, etc.

Adequacy of AFD's research capacity in meeting the national aquaculture development needs

National aquaculture development priority	Priorities	Adequacy of Facilities	Adequacy of personnel
Development of better feed	• Improvement of the moist pellet feed	2/3	3
Fish disease	• Fish disease diagnosis	2/3	2
	• Fish health management	2	2
Fish culture in exposed waters	• Cage design	2	1
	• Environmental assessment	2	2
Alternative species for culture	• Culture trial of new species	3	3

Note: 1 - no capacity; 2 - inadequate; 3 - adequate; 4 - good; 5 - excellent

III. 4 Programs of the Key Aquaculture Research Institutions

List of the programs of the four aquaculture research organizations (see item VI for the list) responded to this survey

Institutions	Priority research areas	Objectives	Date
HKCityU	Nitrogen budget of grouper	• To determine the nitrogen budget for the areolated grouper and the mangrove snapper	1993
HKCityU	Artificial feed of grouper	• To determine the nutritional requirement of the areolated grouper • To formulate a suitable artificial feed for the areolated grouper	1993
HKCityU	Toxicity tolerance of fish	• To establish safety criteria of various pollutant with respect to culture activity	1996 -
HKUST	Co-culture of algae and pearl oyster	• To achieve ecological balance • To minimize effect on environment • To optimize the qualitative and quantitative yield of aquaculture species	1993
HKU	Induced spawning in fish and shrimp	• To study regulation of hormone release	1980 -
HKU	Development of transgenic (growth hormone) technology	• To develop transgenic fish/shrimp • To study molecular biology of growth hormone	1980 -
HKU	Fish diseases	• To develop vaccine for shrimps	1986 -
HKU	Redtides and toxins; PSP occurrence	• To study toxin redtides and ocean currents	1978-

Institutions	Priority research areas	Objectives	Date
HKU	Fish environmental physiology/biochemistry	• To study fish environmental physiology and chemistry	1970 -
HKU	Dinoflaggelate toxicology	• To study PSP production vs cell cycle in dinoflaggelates	
HKU	Scientific fish culture	• To study recycled water system	1970 -
BaptistU	High potency feed for mariculture	• To provide a more efficient feed for mariculture	1995
BaptistU	Use of sewage effluent for fish culture	• To find a cost effective method to treat sewage effluent • To provide alternative source of water supply for pond fish culture	1993-1996
BaptistU	Heavy metal in cultured fish	• To assess level of heavy metal contamination in cultured fish	1995-

Number of research personnel of the four research organization by area of specialization

Specialization	Ph D	M Sc	B Sc	Res. Assist.	Total
Biological sciences	20	10	23	8	61
Physical and engineering sciences	1				
Social sciences					
Economics	1				
Legal studies					
Other (please specify)					
Total	22	10	23	8	63

III. 5 Dissemination and Utilization of Research Outputs

Target groups	Methods used for dissemination of research outputs
Administrators and Managers	Consultative committee
Fishfarmers	Consultative committee
Research community	Conferences; Scientific reports; Meeting reports; Journal publications
Extension community	Meeting reports
General public	Feature articles

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Limited funding • Difficulty in coordinating research conducted by academic institutions	• Different funding criteria used by academic institutions	Improved communication with academic research institutions
Legal aspects			
Information			
Human resources & research competence	• Limited expertise in fish disease management & culture in exposed water		• Regional information exchange and cooperation
Research facilities			
Research environment	• Lack of applied research • Difficulties in motivating academic research institutions to conduct applied research	• Low priority given to applied research • Difficulty in obtaining the university research grants • Heavy administrative load	• Establishment of special research funds • Establish specific funding for aquaculture research
Others (please specify)			

An aquaculture research need that is not addressed through existing research programs and projects is the spawning and breeding of marine cultured fish species (example, groupers). Hong Kong does not have the capacity nor the basic condition for developing hatcheries in marine finfish. Research efforts by neighboring countries in the region on artificial production of healthy fry for culture will be a cost-effective solution to the problem.

IV. List of On-Going Projects of Aquaculture development agency

Project title	Impl. Date	Expected outputs	Target beneficiaries	Implementing organizations
Improvement of culture conditions	1989-	• To increase water circulation • To reduce raft density • To reduce self-pollution	• Fishfarmers • Administrators • Environmentalists	• AFD • (Government)
Development and extension of better feed	1990-	• To reduce self-pollution • To provide balanced diet • To increase feed efficiency	• Fishfarmers • Administrators • Environmentalists	• AFD • Tertiary institutions (research) • Fishfarmers (field trials, feedback and suggestions) • Fish marketing organization (feed production)
Fish disease and fish health management	1993-	• To reduce self-pollution • To provide balanced diet • To increase feed efficiency	• Fishfarmers • Extension staff	• AFD • Fishfarmers (reports on farm practices) • Tertiary institutions (research)
Fish culture in exposed waters	1991-1992 1996-	• To find new culture sites • To improve conditions in sheltered fish culture zones	• Fishfarmers • Administrators • Environmentalists	• AFD • Fishfarmers (collaborative trials, provision of fish stocks) • AFD (sea cage and water quality monitoring) • Other govt departments(site selection)
Alternative species for culture (note: this is yet in the planning stage)	1996	• To reduce market competition • Possibly undertake integrated farming to improve environment	• Fishfarmers • Environmentalists	• AFD • Fishfarmers (field trials) • Tertiary institutions (research)

V. List of On-going Projects of Aquaculture Research organizations

Project titles	Imple m'nt date	Target beneficiaries	Expected outputs	Participating Organiz.	Budget (HK$)
Co-culture of algae and pearl oyster	1993-			HKU + Hainan Institute	300,000
Improved peptide analogous for controlled reproduction and growth in fish	1994-		Induced breeding	HKU	US$ 0.07 m (Biotech. Res. Institute)
Physiology-biochemistry of isolated eel chloride cell	1995-		Scientific knowledge	HKU	100,000

Project titles	Implem' nt date	Target beneficiaries	Expected outputs	Participating Organiz.	Budget (HK$)
Toxic effects of redtides	1990-		Scientific knowledge	HKU	US$ 0.02 m (Strategic Res. Grant)
Remote sensing and ground truthing of red tides	1995-		Scientific knowledge	HKU	US$ 0.05 m
Hormonal control of Ca-P metabolism during induced gonadal development	1990-		Scientific knowledge	HKU	US$ 0.073 m (Research Grants Council)
Intensive fishfarming using recycled water	1991-		Scientific knowledge	HKU	30,000 US$ 0.06 m (RGC)
Neural control of reproduction and growth in fish	1992-		Scientific knowledge	HKU	US$ 0.06 m (RGC)
Cloning and expression of GnRH in fish	1993-		Scientific knowledge	HKU	30,000 US$0.06 m (RGC)
Functional characterization of goldfish D1 dopamine receptor cDNA	1993-			HKU	30,000
Cloning expression of gene for goldfish dopamine D2 receptor	1994-			HKU	US$ 0.01 m (ROC)
Environmental toxicology - toxins in seafood	1995-		Scientific knowledge	HKU	US$ 0.02 m
Cell cycle and toxic red tides	1994-		Scientific knowledge	HKU	100,000
Shrimp endocrinology	1994-			HKU	80,000
Cloning of growth hormone gene in shrimp	1995-			HKU	US$ 0.08 m (ROC)
Regulation of GnRH, GTH and growth hormone secretion in fish	1994-			HKU	70,000
Regulation of GnRH gene expression	1994-			HKU	US$ 0.07 m (Biotech. Res. Institute)
Bacterial expression of neuropeptide Y	1995-			HKU	100,000
Regulation of eel chloride cell	1995-	Fish environ. physiology	Scientific knowledge	HKU	100,000
High Potency Feed	1994-	Fishfarmer	application to mariculture industry	HKBU + AFD	4.66 m
Toxicity tolerance of fish & other marine organisms	1996-	Environmental Protection Fisheries, fish farmers	Scientific knowledge	CityU	

VI. List of the Research Organizations Responded to this Survey

1. Hong Kong University of Science and Technology
2. University of Hong Kong
3. City University of Hong Kong

India

I. Background

Fish culture in India is hundreds of years old. However, the basis for aquaculture practices was laid down by constructing a fish farm with facilities for breeding, rearing and stocking of carps in 1911 in the Madras state (now Tamil Nadu). The Advisory Board of the Indian Council of Agricultural Research in its memorandum of 1944 commenced sponsoring ad hoc research schemes by state governments and universities on different aspects of fish culture. The Government of India established the Central Inland Fisheries Research Station (now CICFRI) at Barrackpore, W. Bengal in 1949 under which a pond culture station was established at Cuttack, Orissa (Now CIFA, Bhubaneswar). The culture of Indian major carps and Chinese carps was undertaken at Cuttack and by 1957 the techniques of induced breeding, seed rearing and culture of carps was developed at this station. The mixed culture technology (polyculture of carps) developed at the pond culture division in Cuttack was tried in several states from 1971 onwards providing a strong base for scientific carp culture in India.

The polyculture (called composite fish culture) technology in which 3 Indian major carps, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* are cultured along with three fast growing Chinese carps, *Hypophthalmichthys molitrix*, *Ctenopharyngodon idella* and *Cyprinus carpio var. Communis* gave yields of 2-10 tonnes/ha/yr by the year 1977 in various states. By this time the culture and induced breeding practices of air-breathing fishes and brackishwater fishes were also developed giving production rate at 1-4 tonnes per ha/yr. Air-breathing fishes cultured are *Clarias batrachus*, *Heteropneustes fossilis*, *Channa punctatus* and *Anabas testudineus*. The brackishwater fish cultured in India include *Mugil cephalus*, *Lates calcarifer* and *Chanos chanos*. The technology for culture of brackishwater prawn, *Penaeus monodon* and *P. indicus* was also developed which gives production rates of 1-3 tonnes/ha/yr. Recently breeding, larval rearing and culture of freshwater giant prawn, Macrobrachium rosenbergii has also been developed. It gives yields of 1-3 tonnes/ha/yr in 2 to 3 crops.

Carps and catfishes are cultured in ponds, reservoirs, lakes, cages and pens. The brackishwater fishes and prawn are cultivated in coastal areas in brackishwater ponds. The freshwater prawn is cultivated in inland areas and generally cultured in ponds. The total aquaculture production in India was 1.04 million tonnes in 1993-94. The total fish seed production in the country has gone above 14,000 million fry which is still not sufficient to stock a pond area of 0.738 million ha. The average rate of aquaculture production has risen to 2-4 t/ha/yr depending on the species stocked and the system of culture. The total annual fish production of the country is expected to increase to 8.5 million tonnes from the present 4.9 million tonnes. The major portion of this increase (more than 2.5 million tonnes) is expected to come from aquaculture; hence aquaculture is being given highest priority in the agricultural sector. As a result of this policy, the outlay of fisheries was increased by more than 300% i.e. from 99 crores in the Seventh Plan to Rs.400 crores in the Eighth Plan. These outlays are expected to more than double the employment opportunities in the aquaculture sector besides increasing the total fish production. The country exported about 2.25 lakh tonnes of fish during 1993-94 earning foreign exchange worth Rs.2105 crores.

Fisheries and aquaculture in India have witnessed an impressive transformation from a highly traditional activity to one based on a well developed and diversified infrastructure with immense potential for industrialization. India is the seventh largest producer of fish in the world and the second largest producer of inland fish after China. Aquaculture accounts for about 1 million tonnes or 58% of inland fish production. By the year 2000, it is expected that aquaculture would account for 70% of the production of the inland sector. Total aquaculture production for 1993/4 was 1.04 million tonnes from a production area of 0.738 million ha,

contributing 0.84% to GNP. About 59.6 million persons were directly employed in aquaculture during the year.

Keeping in view the immense potential and prospects of fisheries and aquaculture development in the country, the Eighth Plan policies and programmes of the sector were directed at increasing employment opportunities and sustained fish production by adopting an integrated approach. Promotion of aquaculture activities are conceived through development of inland and brackishwater resources. The growth rate from aquaculture was expected to be 5- 6%. The per capita availability of fish was targeted at 5 kg per annum, from the 3.5 kg per annum prevailing at the end of 7th Five Year Plan. In order to meet these objectives, the outlay for Fisheries was also increased by more than 300%, i.e., from Rs. 99 crores[3] in the 7th Plan to Rs. 400 crores in the 8th Plan.

II. National Aquaculture Development Plan

The Ministry of Agriculture is responsible for the formulation and implementation of the national aquaculture development plans.

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

Objectives of aquaculture development plan	Priorities of aquaculture development plan
• To evolve economical aquaculture systems and integration of aquaculture with agriculture, horticulture and livestock • To evolve culture technologies suitable to Indian conditions for coldwater fish	• Integration of aquaculture with agriculture, horticulture, animal husbandry, etc. • Socio-economic studies on aquaculture and its integration with agricultural activities and economic evaluation of various aquaculture technologies
• To evolve semi-intensive and intensive aquaculture technologies for prawn. • To develop prawn hatcheries for both freshwater and marine prawns for the purpose of raising seed	• Development of semi-intensive culture technologies for brackishwater and freshwater prawn • Technologies for seed production and culture of marine and freshwater crustaceans • Aquaculture engineering, specially hatchery construction, pond, pen and cage construction/management of large water bodies
• To evolve economical culture systems (pond, pen and cage) for marine and brackishwater fish, including seed production of such species in hatcheries	• Establishment of hatcheries • Maturation and seed production of brackishwater and marine fish, carp, molluscs, • Development technologies for seed production and culture of molluscs, including bivalves
• To evolve semi-intensive and intensive culture technologies for seaweed of commercial importance, and to culture fish food organisms	• Culture and harvesting technologies for seaweed • Nutrition and feed formulations for cultivable fish species, shellfish and other aquatic organisms of cultural value
• To achieve basic and applied research solutions to problems in fish and shellfish physiology, nutrition, genetics, pathology, microbiology, pond and reservoir, lake, cage and pen environments	• Development of basic research facilities for work on various technical aspects
• To undertake selective breeding of rohu, catla, and mass produce fry and fingerlings of silver carp and common carp	• Semi-intensive and intensive carp culture, with production target of 15-25 tonnes/ha/yr • Intensive carp culture in running waters • Semi-intensive culture of catfish
• To evolve and commercialize culture technologies of oyster producing freshwater pearl and marine pearl	• Development of culture technology for marine oysters and pearl culture • Development of culture technologies for freshwater mussels and freshwater pearl culture
• To transfer technologies to users • To train farmers, trainers	• Extension, teaching and training of farmers, extension workers, teachers, etc.

[3] Crore = 1 million

II. 2 Process followed in formulating the aquaculture development plans and priorities

Processes	Criteria	Participants
Consultative approach at different levels, e.g., Planing Commission, Ministry of Agriculture, ICAR, State Fisheries Departments, advisory research committees, other government agencies both at national and state levels	• National Development Plan • National aquaculture development needs • Regional development needs • Local development needs • Availability of water resources • Fish farmers needs • Expected employment and income generation • Availability of resources at national, state, regional and local levels	• Ministry of Agriculture and Cooperation, ICAR, Department of Environment, State fisheries departments • Other government agencies and departments • Research institutes • State agricultural universities and fisheries colleges • Fisheries and animal husbandry ministries at state levels

The strategies used for implementation of the national aquaculture development plans are:

- Enhancing production and productivity of fishfarmers.
- Enhancing total aquaculture production by developing culture technologies of finfish, shellfish and seaweed, etc., for freshwater, brackishwater and seawater resources of the country.
- Development of freshwater and marine pearl culture and culture of freshwater mussels, marine oysters, bivalves and sea cucumber.
- Development of infrastructure training and demonstration for development of human resources for aquaculture, including integrated aquaculture.
- Socio-economic studies in aquaculture and diversification of culturable species and standardization of various aquaculture systems with maximum economic profitability, sustainability and environmental stability.
- Selective breeding of rohu, catla, silver carp and common carp.
- Development of efficient and economical fish and prawn feeds.
- Disease prevention and control.

II. 3 Implementation of the National Aquaculture Development Plans

Action plans and objectives of the national aquaculture development plan

Action plans	Objectives	Target beneficiaries	Expected results
Freshwater carp culture	• To increase productivity and production of carp through culture systems • To integrate carp culture with agriculture, horticulture, animal husbandry. etc. • To extend carp culture to various climatic zones through the Fishfarmers Development Agencies	• Carp farmers • Carp hatchery managers and seed producers • Government sector	• Carp productivity above 2-7 t/ha/yr • Carp productivity in intensive culture of 15-25 t/ha/yr • Extension of carp culture to more than 22.54 lakh ha
Culture of catfish and air-breathing finfishes	• To develop extensive and semi-intensive culture technologies • To develop and standardize induced breeding and larval rearing technologies • To integrate air-breathing fish culture and paddy culture	• Catfish and airbreathing fish farmers • Entrepreneurs • State fisheries departments • Aquaculturists	• Production rates of 5-10 t/ha/yr • Running water and water exchange rates of 30-100 t/ha/yr • About 1 million larvae • Integrated of paddy cum fish culture technology package

Action plans	Objectives	Target beneficiaries	Expected results
Breeding, hatchery rearing and culture of prawns and brackishwater fish	• To develop standard technology for brooder-raising for brackishwater and freshwater prawns	• Prawn farmers • Brackishwater Farmers Development Agencies (BFDAs) • State fisheries departments	• Technologies for broodstock and larval rearing and quality seed production through breeding in captivity • Standard culture technologies for prawns and brackishwater fish • Development of hatcheries
Fish seed and hatchery development	• To establish fish seed hatcheries • To ensure the availability of quality fish seed to fishfarmers	• Fishfarmers • Fish hatchery operators • State fisheries departments • Private and cooperative seed producers	• Establishment of 47 commercial fish seed farms and hatcheries in the country
Integration of aquaculture livestock and poultry	• To develop unified farming systems integrating aquaculture with agriculture, livestock, poultry, horticulture	• Aquaculturists • Agriculturists • Entrepreneurs	• Development of an integrated aquaculture-agriculture-livestock technology
Development of recreational and coldwater fisheries	• To develop breeding, larval rearing and culture technologies for coldwater fish and ornamental fish	• Coldwater area fishfarmers • Private sector (entrepreneurs) • State fisheries depts.	• Standard economically viable technologies for breeding, seed raising and culture of coldwater and ornamental fish
Fisheries development of floodplain lakes	• To develop about 2.0 lakh ha of floodplain lakes for culture and capture fisheries	• State fisheries depts. • Fisheries cooperatives	• Standardized package of practices for culture in floodplain lakes to increase inland fish production
Cage culture of fish in reservoirs	• To develop economically viable technology for cage culture in reservoirs	• State fisheries departments • Fisheries cooperatives	• Development of package of practices for cage culture of important fishes in reservoirs
Human resources development	• To develop trained and skilled fisheries personnel	• Fisheries departments • Fisheries colleges • Fisheries institutions • State Agricultural Univs.	• Conduct of refresher courses for fishery workers, demonstrators, teachers, extension workers and researchers

Changes and emerging issues resulting from implementation of the aquaculture development plan

Action plans	Changes or effects	Issues	Actions required
Freshwater carp culture	• Increase in aquaculture production by 5-6% per annum; and increase in inland fish production • Increase in aquaculture area • Increase in average productivity from ponds and tanks from 900 kg/ha/yr to 2130 kg/ha/yr over 10 yrs	• Intensification of aquaculture • Development of indigenous feeds for aquaculture • Need for disease prevention and control measures • Improvement of fish processing and marketing • Need to develop environmentally	• R&D on intensification of carp culture • Running water and recirculatory water systems for carp culture • Increase in funding

Action plans	Changes or effects	Issues	Actions required
		friendly and sustainable technologies	allocation • Strengthen extension program
Culture of catfish and air-breathing finfishes	• Development of breeding and larval rearing technologies for certain air-breathing fishes • Increase in culture demonstration of catfishes and air-breathing fishes • Increase in financial support for R&D	• Development of intensive and semi-intensive aquaculture technologies • Disease control and prevention • Feed for intensive aquaculture and larval rearing	• R&D on intensification of aquaculture on catfishes and air-breathing fishes • Need to develop new techniques on breeding and larval rearing
Breeding, hatchery rearing and culture of prawns and brackishwater fish	• Controlled breeding of prawns and fishes • Successful hatchery techniques for Indian prawn and fishes • Culture technology for prawns and important fishes	• Establishment of feedmills • Need for infrastructure for brackishwater finfish culture	• BFDAs established to promote brackishwater aquaculture
Fish seed and hatchery development	• Construction of 47 commercial fish seed farms and hatcheries • Achievement of self-sufficiency in fish seed requirements	• Need to develop additional hatcheries with improved water quality management fir better survival rates and seed growth	• Certain balanced feed formulation developed for hatchery rearing • Improved water quality management practices evolved for higher survival rate and better growth
Integration of aquaculture livestock and poultry	• Development of technologies for integration f aquaculture with livestock, poultry and horticulture • Better management practices for recycling of energy, nutrients and organic materials (in progress)	• Need to develop a sustainable integrated aquaculture system for small farmers • Recycling of agricultural wastes for aquaculture purposes	• Research on technologies to suit recycling of organic wastes and energy in integrated aquaculture
Development of recreational and coldwater fisheries	• Coldwater fisheries of golden Mahseer, trout now taken up by state fisheries departments and farmers • Larval rearing of coldwater fishes and breeding of recreational fishes now being done by state fisheries departments and private entrepreneurs	• Development of infrastructure for coldwater and recreational fishes • Need to develop feed for brood fishes and larvae • Disease control • Need to refine breeding and larval rearing technologies	• Development of breeding and larval rearing technologies using local resources
Fisheries development of floodplain lakes	• Identification of about 2.0 lakh ha suitable for such fisheries • Breeding culture and harvesting techniques now being evolved	• Development of infrastructure and awareness among fisheries departments of potential of floodplain lake fisheries	• Managerial culture practices (now being evolved)
Cage culture of fish in reservoirs	• R&D efforts for construction of cheaper cages are in progress • Stocking with quality fish seed has started giving higher rate of production	• Cost-effective technology for cage construction and installation • Balanced feed for cultured fish • Disease and environmental control measures	• Use of indigenous design for cages • Ensure availability of quality fish seed for stocking
Human resources development	• Strengthened human resource development programs in 8 fishery institutions if ICAR, as well as in MAC and MFPI • Increase in the number of trained fishery aquaculturists in the country	• Need to assess manpower requirements for aquaculture • Need to address aquaculture needs in preparing academic plans • Greater emphasis on practical training • Development of course manuals on aquaculture	• Design more courses in aquaculture and other specialized fields

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspects	• Lack of sufficient infrastructure • Weak interagency & institutional linkages	• Lack of funds • Weak institutional linkages	• Budgetary allocation for infrastructure • Strengthen linkages and improve coordination
Legal aspects	• Conflicts between aquaculture and agriculture on environment	• Lack of clear guidelines for aquaculture farm and area development	• Legal guidelines on aquaculture areas/farms
Information	• Weak technology transfer • Lack of technology packages	• Lack of funds for publication production and distribution • Lack of awareness on aquaculture technologies	• Strengthen and expand extension services • Develop technology packages • Increased budgetary allocation for extension
Human resources	• Lack of skilled extension workers at block and village levels • Lack of training courses, demonstrations • Lack of coordination among agencies and institutions	• Lack of funds • Lack of information on actual human resources requirements for aquaculture development of a country	• Increased budgetary allocation • Increased number of courses, training programs, and fellowships • Coordinated training & HRD programmes
Technical aspects	• Lack of information on feed ingredients, feeds & feedmills • Lack of facilities for disease diagnostics, feed and seed production, & processing	• Improper processing, storage and distribution of feeds cost-wise and efficiency wise	• Establishment of feedmills, hatcheries, postharvest processing & storage plants, disease diagnostic facilities
Physical and environment aspects	• Identification of further aquaculture sites in fresh, brackish and marine waters • Lack of pollution, water and mineral seepage monitoring	• Lack of survey data on water bodies • Uncontrolled use of fertilizers and feeds • Pollution • Unplanned development of aquaculture farms	• Survey & assessment of potentials of water bodies • Control and monitoring aquatic pollution
Socio-economic aspects	• Difficulty in obtaining credits & loans • Lack of facilities for marketing • Inadequate marketing channels	• Funding agencies are not well informed of potentials of aquaculture technologies • Inadequate facilities for processing and marketing	• Increased access to credits & support of aquaculture by funding agencies • Development of marketing channels

III. National Aquaculture Development Research

III. 1 Objectives and Priorities of the National Aquaculture Research

The Indian Council of Agricultural Research (ICAR) is the agency responsible for the planning and implementation of the national aquaculture research program. ICAR's main functions are to conduct research, development extension and educational research in agriculture, fisheries, aquaculture, animal husbandry and related disciplines and management of research in these disciplines. It is also the apex body in the formulation and implementation of research schemes, coordination and management of 49 research institutes, 30 national centers, 78 All-India Coordinated research projects, and 28 agricultural universities.

The goals and objectives of the national aquaculture research sector are:

- To evolve aquaculture systems that are economical, sustainable and eco-friendly, and integrate aquaculture with agriculture, horticulture, livestock and poultry.
- To increase production and to evolve culture technologies suitable to Indian conditions.
- To evolve semi-intensive and intensive aquaculture technologies for prawns.
- To evolve economical culture systems (ponds, pen, cage) of marine and brackishwater fishes, and produce seed of these fishes through hatchery management
- To evolve semi-intensive and intensive technologies for seaweeds of commercial importance and for culture of fish food organisms
- To evolve and commercialize culture technologies of freshwater pearl and marine pearl producing oysters; and to develop technologies for freshwater mussel and mollusc culture and marine bivalve culture.
- To develop solutions to various technical problems which solutions would lead to economical and efficient aquaculture
- To transfer aquaculture technologies to users, train farmers, trainers and teachers; and develop human resources for aquaculture.

Priorities of the aquaculture development research sector

Priority Research Areas	Research Programs	Expected outputs	Implement'g Organiz.	Target beneficiaries	Date imp.
Semi-intensive and intensive mixed carp culture	• Mixed culture • Running water culture • Cage and pen culture	• Increased production	CIFA	Fishfarmers Entrepreneurs State fisheries depts.	1992
Semi-intensive catfish culture	• Semi-intensive culture of various catfish species • Intensive culture • Breeding and larval rearing technology	• Increased production	ICAR, CIFA	Fishfarmers Entrepreneurs	1994
Carp seed production and rearing	• Semi-intensive and intensive rearing of fry • Semi-intensive and intensive rearing of Chinese carps	• Increased stocking density and higher survival rate	ICAR, CIFA	Seed producers Farmers State fisheries depts.	1992
Semi-intensive brackishwater prawn and shrimp culture and seed production	• Culture and production of brackishwater prawn and shrimps	• Increased production • Improved seed	ICAR; CIBA CMFRI	Prawn farmers Entrepreneurs State fisheries depts.	1992
Semi-intensive freshwater prawn breeding seed production and culture technologies	• Raising of brood prawn in freshwater • Breeding and seed production • Culture of freshwater prawns	• Increased production of freshwater prawn • Production of sufficient seed	ICAR; CIFA DBT	Prawn farmers Entrepreneurs State fisheries depts.	1994
Maturation and seed production and culture of brackishwater fishes	• Maturation of brackishwater culturable fishes • Seed production • Culture technology	• Increased production • Development of quality broodstock	ICAR; CIBA CMFRI	Fishfarmers Entrepreneurs BFDAs	1992
Technology for seed production and culture of marine and freshwater crustaceans	• Seed production technology under controlled conditions • Culture technology for crustaceans	• Increased production of crabs • Increased seed production	ICAR; CMFRI CIFA; CIBA	Mariculturists Entrepreneurs State fisheries depts.	1992
Development of seed production and culture technology of molluscs	• Culture technology • Seed production technology	• Development of economically viable seed production and culture technology	ICAR; CMFRI CIBA; CIFA	Mollusc growers State fisheries depts. Entrepreneurs	1992

Priority Research Areas	Research Programs	Expected outputs	Implement'g Organiz.	Target beneficiaries	Date imp.
Development of culture technology for marine oysters and pearl culture	• Culture technology for marine pearl oysters	• Commercial scale production of marine cultured pearl	ICAR; CMFRI Coastal state fisheries depts.	Pearl culture industry Oyster culture industry	1992
Development of technology for freshwater pearl culture and seed production of pearl mussels	• Development of technology for freshwater pearl culture; seed production and culture technology for pearl-producing mussels	• Commercial scale production of freshwater pearl and mussel seed	ICAR; CIFA	Freshwater pearl culturists Fishfarmers State fisheries depts.	1992
Studies on physiology of digestion, respiration and reproduction of cultivable fishes	• Development of hormones and chemicals for fish breeding;	• Commercialization of hormones and chemicals for fish breeding; controlled maturation and breeding; control of pollution and metabolism	ICAR; CIFA (CIBA, Fisheries College, CMFRI)	Fish breeders Hatchery management State fisheries depts. Entrepreneurs	1995
Pond microbiology, pond energetics and environmental monitoring	• Assessment of the role of microbials in nutrient recycling in ponds • Determination of food chain and pond energetics	• Package of practices for microbial roles in pond fertilization • Knowledge of pond energetics and its use in production	ICAR; CIFA CIBA; Fisheries Colleges	Fishfarmers Entrepreneurs State fisheries depts. FFDAs	1990
Fish and shrimp pathology and disease control	• Development of immunodiagnostic kits	• Disease prevention and control • Diagnostic kits for fish disease	ICAR; CIFA CIBA Fisheries College CMFRI; CIFE	Fish breeders Entrepreneurs State fisheries depts. FFDAs	1990
Fish genetics and selective breeding	• Selective breeding of carps • Gene manipulation and gynogenesis	• Breeding of selected strains of rohu and catla	ICAR; CIFA CBI; NBFGR Fisheries College	Fish breeders Hatchery managers State fishery depts.	1992
Socio-economic studies	• Estimation of the production function of mixed culture • Determination of efficiency of different systems of aquaculture	• Economic analysis of different aquaculture systems	IAR; CIFA CIBA; CIFE (Fisheries College)	Fishfarmers Entrepreneurs State fisheries depts. FFDAs; BFDAs	1995
Integrated fish farming and recycling of organic wastes	• Integration of aquaculture with horticulture, livestock, poultry • Recycling of wastes in aquaculture	• Package of practices for integrated aquaculture	ICAR; CIFA CIBA (CMFRI, Fisheries College)	Fishfarmers Entrepreneurs State fisheries Depts.)	1993
Aquaculture engineering and running water aquaculture	• Pond construction engineering • Running water culture for carp	• Indigenous technology for pond construction	ICAR; CIFA (CIBA, CMFRI, CIFRI)	State fisheries depts Entrepreneurs Fishfarmers	1994
Sewage-fed fisheries and aquafarming	• Development of technology of sewage water recycling and integrated farming	• Increased production in sewage water • Technology of sewage water management for aquaculture	ICAR; CIFA	State fisheries depts Urban populations Municipalities	1993
Breeding, nursery management and culture of important frog species	• Development of hatchery technology if commercially important frogs • Breeding, hybridization and culture of frogs	• Technology for hatchery, breeding and culture for frogs	ICAR; CIFA	State fisheries depts Entrepreneurs	1990

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

The priority-setting exercise and formulation of action plans are done by the working group set up by the Planning Commission for five-year plan periods. The Committee prepares a status paper on the development of fisheries and aquaculture, setting the goals and objectives of the national development plans for aquaculture. ICAR sets the research and development projects/programmes as guidelines for its institutes and other bodies.

Type of organiz.	Processes	Criteria	Participants
National aquaculture research coordinating agency, i.e., ICAR	Consultative process	• Regional aquaculture development needs • Local and farmers' needs • Expected employment generation and income generation • Availability of financial resources at all levels	• ICAR • Dept. of Agriculture and Cooperation • Research organizations, e.g., CIFA, CIBA, CIFRI, CIFE, CMFRI • National Bureau of Fish Genetics • National Research Center on Coldwater Fishes • Planning Commission • State fisheries departments
Research organizations	Consultative process	• Research competence • Local and farmers needs • National and regional development needs • Availability of resources and technology	• Research organization in consultation with ICAR and other institutes

III. 3 National Aquaculture Research Capacity

As shown in the following table, India has a large number of organizations, agencies and institutes involved in aquaculture research and development.

Research organizations	Affiliation	Areas of competence
Central Institute of Freshwater Aquaculture (CIFA)	Ministry of Agriculture	• Freshwater carp, catfish, prawn, pearl culture and seed production • Integrated aquaculture and manpower resources development • Fish reproduction, genetics, microbiology, engineering, pathology, etc.
Central Institute of Brackishwater Aquaculture (CIBA)	Ministry of Agriculture	• Brackishwater aquaculture of prawns and fishes • Manpower resources development
Central Marine Fisheries Research Institute (CMFRI)	Ministry of Agriculture	• Culture of marine fishes, molluscs, crustaceans, algae, etc.
Central Institute of Fisheries Education (CIFE)	Ministry of Agriculture	• Culture of prawns and fishes, seed production • Manpower resources development
National Research Center on Coldwater Fisheries (NRCCF)	Ministry of Agriculture	• Culture of golden mahseers and trouts • Breeding and Seed production
Central Inland Fisheries Research Institute (CIFRI)	Ministry of Agriculture	• Culture in floodplain lakes, beels, mans, chatirs and reservoirs and rivers
National Bureau of Fish Genetics resources (NBFGR)	Ministry of Agriculture	• Genetic resources conservation and breeding • Gene banks
Fisheries College, Mangalore	Ministry of Agriculture, State of Karnataka	• Freshwater and brackishwater carp culture • Prawn culture • Seed production
Marine Products Export Development Authority (MPEDA)	Ministry of Commerce	• Culture and seed production of brackishwater prawns
State Fisheries departments	Ministry of Fisheries & Ministry of Agriculture, State governments	• Implementation of aquaculture development and seed production • Integration of aquaculture and agriculture
Agency for development of aquaculture in Kerala	Ministry of Agriculture, Govt. of Kerala	• Development of aquaculture and seed production in Kerala
State agriculture universities	Ministry of State Agriculture Ministry of Agriculture	• Human resources development for aquaculture

Fisheries College, Cochin	Ministry of Agriculture, Govt. Kerala	• Freshwater and brackishwater aquaculture
Fisheries College, Tuticorin	Ministry of Veterinary and Fisheries, Govt. of Tamilnadu	• Freshwater and brackishwater aquaculture
School of Environmental Sciences, Madurai Kamaraj Unit, Tamilnadu	Ministry of HRD, Govt. of Tamil Nadu	• Freshwater aquaculture
Fisheries College, Orissa University of Agriculture and Technology, Orissa	Ministry of Agriculture Govt. of Orissa	• Freshwater and brackishwater aquaculture
Department of Aquatic Biology and Fisheries, University of Kerala	Ministry of Education, Govt. of Kerala	• Freshwater and brackishwater aquaculture

Aquaculture research capacities of India can be considered as adequate as shown in following table.

Aquaculture development priorities	Priority research needs	Adequacy
Freshwater aquaculture of carps	Semi-intensive culture of carps in ponds	5
	Intensive culture of carps in running water	4
	Cage and pen culture of carps	4
Freshwater aquaculture of catfish and	Semi-intensive culture of catfish	4
air-breathing fish	Intensive culture of catfish in running water/water exchange	3
Seed production of carp and catfish	Seed production of over 14,000 million fry carp	5
	Quality seed production of over 2 million fry of catfish and air-breathing fish	4
Freshwater prawn culture and seed	Semi-intensive culture of freshwater prawn culture	4
production	Production of 5 million PL of M. rosenbergii per year	4
Freshwater pearl culture and culture	Economical culture of freshwater pearl at commercial scale	4
of freshwater mussels and their seed	Culture of freshwater mussels and seed production	4
Brackishwater pearl culture and	Economical culture technology for brackishwater pearl culture	4
culture of oysters, crustaceans, etc.	Culture technology for oysters and crustaceans	3
Brackishwater fish culture	Economical culture technology for brackishwater fish	4
	Seed production and hatchery facilities for brackishwater finfish	3
Mariculture of finfish and seaweeds	Economical culture technology for marine fish	3
and marine crustaceans	Economical culture of seaweeds	4
	Technology for the culture of marine crustaceans	3
Seed production and culture of	Economical technology for seed production of molluscs	4
molluscs, including bivalves	Culture technology of molluscs including bivalves	4
Basic research needs in technical areas, including fish pathology,	Basic research facilities in fish reproduction, breeding, metabolism, genetics, selective breeding, etc.	5
aquaculture engineering, fish nutrition and feed formulation, etc.	Basic research facilities in microbiology and pond environment monitoring and fish pathology	5
	Basic research facilities in aquaculture engineering and economics	4
	Basic research facilities in fish nutrition., feed formulation, bioenergetics and integrated farming	5
Integration of aquaculture with agriculture, horticulture, livestock and poultry and paddy-cum-fish culture	Integration of aquaculture with agriculture, horticulture, livestock and poultry	4
Aquaculture extension and human resources development	Extension of aquaculture technologies to farmers and state fisheries departments, and entrepreneurs	4
	Fishery human resources development for aquaculture	4

a/ 1 - no capacity; 2 - inadequate; 3 - adequate; 4 - good; 5 - excellent

III. 4 Programmes of the Key Aquaculture Research Institutions

List of the programmes of the seven key aquaculture research organizations (see Section VI for the list of organizations).

Program Areas	Impl. organiz	Objectives	Date impl
Physiology of reproduction, digestion, nutrition of carps, catfish and prawn	CIFA	• To develop commercial hormone preparations	1990
Culture, breeding and seed production of carp and catfish	CIFA	• To develop semi-intensive and intensive cage culture of carps and catfish • To develop technology for seed production and rearing of cultivable fish	1988
Culture, breeding and seed production of prawns	CIFA	• Breeding and larval/post-larval rearing of prawns • Culture of prawns	1992
Culture of pearls and molluscs	CIFA	• To develop a package of technology for freshwater pearl culture	1992
Pond microbiology, pond energetics and environmental monitoring	CIFA	• To assess the role of microbials in nutrient recycling in ponds • To determine food chain and pond energetics	1990
Fish genetics and selective breeding	CIFA	• Selective breeding of rohu; genome manipulation and gynogenesis	1992
Socio-economic studies	CIFA	• To estimate production functions • To determine efficiency of different systems of aquaculture	1995
Fish pathology and disease control	CIFA	• To determine role of bacteria, fungus and virus in fish disease • To develop immuno diagnostic kits	1990
Integrated fishfarming and recycling of organic waste	CIFA	• To integrate aquaculture with horticulture, livestock and poultry • To recycle organic wastes	1992
Aquaculture engineering and running water aquaculture	CIFA	• Pond construction engineering and running water carp culture	1995
Sewage-fed fisheries/aquafarming	CIFA	• To augment fish production through sewage water recycling	1993
Breeding nursery management and culture of important frog species	CIFA	• To develop hatchery [techniques] for commercially important frogs • To study breeding, hybridization, seed and culture of frogs	1990
Broodstock development & seed Production of Seabass, grouper	CMFRI	• Induced breeding & farming	1992
Seed production, rearing and sea ranching of Penaeid prawn, clam, pearl oysters, sea cucumber	CMFRI	• Hatchery production, farming & sea ranching • Commercialization and stock enhancement farming of sea cucumber	1984/5 1987
Upgrading and transfer of culture technologies for pearl oyster, mussel & oyster	CMFRI	• Upgrading pearl production • Farming mussel and oyster	1991/92
Feed development of marine organisms	CMFRI	• Mass production of live feed • cost effective feed formulation using local ingredients	1995
Seaweed culture	CMFRI	• Raw material for agar industry	1989
Integration of mariculture with small scale fisheries	CMFRI	• Mariculture technologies	
Breeding and culture of golden mahseer	NRCCF	• To enhance natural stock and rearing of fry & fingerlings in captivity	
Rearing of *Tor* sp. in cages	NRCCF	• healthy & right sized stocking material in natural waters	
Culture and breeding of carp	NRCCF	• Promoting marketable size carp & seed production	
Breeding possibilities of schizothoracids	NRCCF	• Hatchery practices for mass scale seed production of depleting varieties	
Design & development of machinery and aquaculture structure	CIBA	• Development of eco-friendly & locally suitable farm design • Control & monitor seepage	
Study of brackishwater aquaculture practices	CIBA	• Evaluation of existing culture practices and formulation of improvement	

Program Areas	Impl. organiz	Objectives	Date impl
Development of database system for brackishwater fishery resources	CIBA	• Collection and organization of data on brackishwater fishery resources	
Broodstock management, breeding and seed production of brackishwater finfish	CIBA	• Development of captive broodstock of seabass, grey mullet & quality seed production	
Culture of brackishwater finfish	CIBA	• Development of technology packages for sustainable farming of species in ponds and pens	
Breeding of P. monodon & hatchery technologies	CIBA	• Breeding of P. monodon with desirable traits & building up broodstock • Refinement of hatchery technology • Development of quality standard for shrimp seed	
Culture of Prawn & shrimp & mud crab	CIBA	• Development and transfer of shrimp & crab culture technologies	
Feed development	CIBA	• Development of nutritionally balanced feeds for prawns & fish	
Prevention and treatment of diseases	CIBA	• Development of diagnostic tests for fish & shrimp diseases • Understanding of shrimp immune system and development of vaccines	
Soil and water management for shrimp farming	CIBA	• Development of soil & water management practices for sustainable shrimp farming	

Number of research personnel of the seven research organizations by areas of specialization

Specialization	Ph D	M Sc	B Sc	Res. Assist.	Total
Biological sciences	142	209	319	51	721
Physical and engineering sciences	7	13			20
Social sciences		1			1
Economics	4	6			10
Legislation					
Others	1	9	2		12
Total	154	238	321	51	764

III. 5 Dissemination and Utilization of Research Outputs

Target audience	Methods used
Policy planners; Political level	Research reports; Meetings and conferences
Administrators and Managers	Research reports; Conferences, meetings, workshops
Fishfarming community	Fishfarmers' Day; Broadcast media (TV); Demonstrations; Farmers' surveys; Contact with farmers; Training and demonstration; TV and radio talks; Workshops, meetings; Extension pamphlets
Private sector and supporting industries	Demonstrations of aquaculture systems in farmers' ponds; Meetings and group discussions; TV and radio broadcasts
Research community	Training programmes; Meetings
Extension community	Farmers' day; Radio and TV talks; Newspaper; Extension pamphlets

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Lack of infrastructure • Weak institutional and interagency linkages	• Lack of funds • Need to strengthen institutional/organizational linkages	• Allocate funds for development of infrastructure • Strengthen linkages and improve coordination
Information	• Slow technology transfer • Lack of technology packages • Insufficient information delivery systems • Inadequate coordination among related organizations • Lack of awareness on aquaculture technologies	• Lack of funds • Ineffective knowledge transfer to farmers and entrepreneurs • Slow process of information transfer and processing of loans	• Improve and strengthen extension service • Allocate funds for technology transfer • Develop technology packages • Organize training and demonstration on various aspects of aquaculture • Establishment of regional transfer of technology centers
Human resources and research competence	• Lack of skilled extension workers, particularly at block and village levels • Lack of training courses, demonstrations • Coordination among agencies and institutions	• Lack of funds • Lack of information on actual human resources requirements • Inadequacy of expert trainers/teachers	• Increased budgets for HRD • Increased number of courses, training programs, and fellowships (national and international level) • Assessment of human resource requirements • Training for scientists and technicians on handling & operating scientific equipment
Research facilities	• Inadequate research facilities and special equipment • Delays in acquiring equipment grants and supplies	• Lack of funds • Cumbersome process in procuring equipment and supplies	• Allocate funds for equipment and facilities
Research environment	• Inadequate contact between researchers, users and planners of aquaculture • Lack of need-based aquaculture research • Lack of incentives for aquaculture researchers and teachers • Over emphasis on single species crop • Slow pace of research • Lack of funds	• Lack of coordination & consultation between planners, implementers and users of research • Inadequate contact between researchers and farmers, entrepreneurs	• Improved funds for aquaculture research • Increased interaction between researchers and users • Promote need-based research programmes using local resources and inputs • Diversification of species, crop rotation, polyculture, etc

Other suggestions:

- Culture technologies and systems, including breeding, genetic improvement, nutrition and feed, for coldwater species.
- Breeding and seed production of grouper, bream and seabass
- Pathology and immunology of crustaceans and bivalve
- Diagnostics an detection of shellfish diseases
- Probiotics application
- Genetic improvement of seaweed
- Environmental concerns relating to shrimp farming
- Farm construction
- Fish & shrimp quarantine system
- Biotechnology for fish genetics

IV. List of On-going Projects of the Aquaculture Development Agency

Projects	Duration From/To	Target beneficiaries	Expected outputs	Participating organizations	Budget [a/] (in lakhs Rs.)
Freshwater aquaculture	1992-1997	Fishfarmers Entrepreneurs NGOs State fisheries	Development and extension of aquaculture	ICAR & its institutes Govt. agencies State fisheries depts. Fish seed corporations FFDSs	6,000
Integrated brackishwater fishfarm development	1992-1997	Farmers Brackishwater entrepreneurs NGOs Maritime state depts.	Development of brackishwater fishfarmers for integrated aquaculture	ICAR & its institutes Other govt. agencies State fisheries Dept. BFDAs	2,500
Assistance for strengthening fish marketing	1992-1997	Fish markets Fish retailers Consumers Fish stock brokers	Strengthening of fish marketing facilities	Govt. agencies Fish corporations	2,500
Development of derelict water bodies	1992-1997	Fishfarmers Aquaculture entrepreneurs State fisheries depts	Development of swampy and other derelict water bodies lying fallow or are underutilized	Govt. agencies	45
Fisheries development in floodplain lakes	1995-1996	Fishermen & entrepreneurs NGOs	Development of fisheries in floodplain lakes	Govt. agencies	100
Integrated development of reservoirs	1995-1996	Fishermen Women Agriculturists Entrepreneurs	Development of integrated fisheries in reservoirs	Govt. agencies	50
Fish net-making	1992-1995	Fishermen Women Fishnet manufacture.	Making of fishing nets	State fisheries depts. NGOs	1,800
Fishnet-making machine	1995-1996	Fishnet makers Women Fishermen	Development of machines for net manufacture	Govt. agencies State fisheries depts.	100
Bioenergetic pathways and their optimization in fishpond ecosystems	1992-1997	Fishery managers Fishfarmers	Characterization of the intensities of bioenergetic pathways in fish, shellfish ponds Quantification of cycling rates and media interactions of major nutrients and microbial processing Suitable biofertilization measures Channeling of pond production potential through biotechnological approach	ICAR CIFA World Bank	US$ 330,633
Selective breeding of rohu, *Labeo rohita*	1992-1997	Fishfarmers Rohu breeders Hatchery managers	Development of a breeding program of rohu	ICAR Aqaforsk (Norway)	US$ 56,138
Selective breeding of catla		Fishfarmers State fisheries depts.	Development of breeding programs on catla, by selection	Fish. College (Mangalore) Aquaforsk (Norway)	

Projects	Duration From/To	Target beneficiaries	Expected outputs	Participating organizations	Budget a/ (in lakhs Rs.)
Raising of fry and fingerlings of selectively bred silver carp and common carp		Fishfarmers Hatchery manager State fisheries depts.	Raising of fry and fingerlings from selectively bred silver carp and common carp	ICAR Vietnam	
Women in fisheries in Orissa	1992-1996	Tribal women of Orissa	Improvement of the quality of life of 300 families in 3 districts of Orissa through aquaculture	ICAR UNIFEM (UNDP)	20.6

Note: Amount in lakh rupees unless otherwise indicated. a/ Lakh = 100,000

V. List of On-going Projects of Main Aquaculture Development Research Organizations

Projects	Duration From/To	Target beneficiaries	Expected outputs	Implement'g organization	Budget (in lakh Rs)
Optimizing carp production through intensive aquaculture and multiple cropping	1995-2000	Fishfarmers & entrepreneurs	• Optimization of production through intensive rearing of carp spawners, fry, fingerlings & juveniles • Evaluation, standardization and optimization of fish production through multiple cropping • Utilization of larger water bodies for pen and cage culture	CIFA	60
Utilization of domestic sewage in aquafarming	1993-1998	Fishfarmers Urban fish entrepreneurs	• Augmentation of fish production through maximum recycling of sewage water • Higher returns from paddy fields with fish culture and horticulture products from pond bundhs and production and decomposition of sewage fed ecosystem	CIFA	28.26
Seed production and culture of *M. Rosenbergii* and *M. malcomsonii*	1995-2000	Prawn farmers & entrepreneurs	• Mass breeding technology, standardized hatchery, nursery rearing of post-larvae and mono and polyculture *of M. Rosenbergii* and *M. Malcomsonii* • Technology transfer	CIFA	248.65
Mass production of fry and fingerlings and culture of *Clarias batrachus*	1995-1998	Fishfarmers & entrepreneurs	• Establishment of major hatchery and production of fry and fingerlings • Culture of *C. batrachus* • Technology transfer	CIFA	12.1
Studies on physiology of digestion, respiration and reproduction in cultivable fishes	1995-2000	Fishfarmers Fish breeders Fish entrepreneurs	• Commercial preparation of hormonal inducing agent • Commercial production of hormonal pellets for advanced and multiple breeding • Commercial low-cost-efficient feed formulation for establishment of feedmills • Measures for control of fish mortality and reproduction due to pollution	CIFA	40

Projects	Duration From/To	Target beneficiaries	Expected outputs	Implement'g organization	Budget (in lakh Rs)
Pathomorphology & immune pathological studies on microbial diseases, & diseases management & health care through herbal materials of fish and shellfish	1995-2000	Fishfarmers Private agencies and institutions	• Development of suitable vaccines against diseases caused by bacterial and viral agents • Diagnostic kits and herbal medicine development	CIFA	32.262
Socioeconomic studies on freshwater aquaculture	1995-2000	Fishfarmers Private agencies and institutions	• Input-output data on various systems of aquaculture at experimental stations, demonstration centers and farm ponds • Information on yield gaps and socio-economic constraints and advantages of aquaculture	CIFA	19.55
Bioenergetic pathways & their optimization in fish pond ecosystem	1992-1997	Fishery managers Fishfarmers	• Faster and high rate of nutrient and energy transfer in eco-friendly pond ecosystem	CIFA	0.99
Selective breeding of rohu	1992-1996	Fishfarmers Rohu breeders State hatchery managers	• Development of a breeding program for rohu	ICAR (?)	17.98 US$ 0.56m
Center for advanced studies on postgraduate agricultural education and research	On-going	Fishery colleges and universities Fishfarmers & entrepreneurs	• Trained aquaculture manpower	ICAR (?)	US$ 0.91m
Women in fisheries in Orissa	1992-1996	Farmers Tribal women of Orissa	• Training of 300 women carp farmers on carp culture technologies	ICAR	20.6
Development of flow-through system for industrial aquaculture	1994-1997	State fisheries dept. Fishfarmers and entrepreneurs	• Development of a flow-through system for intensive aquaculture for production of table-size fish and juveniles at a high stocking density	ICAR	33.48
National facilities for disease control in fish through quarantine and health certification	*	Fishfarmers & entrepreneurs State fish. depts. Fish seed corporations	• Development of a national facility for quarantine and health certification and control of fish diseases	ICAR	12.48
Biotechnology information system on aquaculture mission mode project on freshwater prawn culture	1990-1997	Scientific and technical staff	• Databases on aquaculture and related subjects, and provision of retrieval services • Computer software and statistical packages for users' needs • Establishment of national and international linkages for selective bibliographic research • Promotion of computer awareness and provision of training	ICAR	23.26
Mission mode project on freshwater prawn culture	1994-1998	Prawn farmers Entrepreneurs State fisheries depts.	• Technologies for breeding, post-larval rearing, seed production and culture of giant freshwater prawn	ICAR	199
Aquaculture as a tool for utilization and treatment of domestic sewage	1993-1999	Consumers Fishfarmers Municipalities	• Technologies for treatment of sewage water fit for aquaculture, and a package of practices for the utilization of sewage water	ICAR	27.6

Projects	Duration From/To	Target beneficiaries	Expected outputs	Implement'g organization	Budget (in lakh Rs)
National Center for freshwater pearl culture	1992-1996	Pearl culturists State fisheries depts. Entrepreneurs	• Technology for freshwater pearl culture and culture of freshwater mussels • Diversification of farm pearl produce leading to gainful employment for women in rural areas	ICAR	11.39
Isolation of GnRH fraction from the crude pituitary extract of various fishes	1993-1996	Fish breeders Fishfarmers Private sector	• Synthetic GnRH product for fish breeding	ICAR	10
Application of plastics in agricultural plant environmental control and agricultural processing	1989-1997	Fishfarmers Plastic processors and manufacturer s	• Package of practices for use of plastics in aquaculture operations	ICAR	22.896
Operational research project and utilization of organic wastes in aquaculture	1994-1998	Fishfarmers & entrepreneurs State fisheries depts.	• Package of practices for the development of aquaculture using organic wastes	ICAR	145.85
Recycling of processed dignocellulosic wastes & cattleshed refuse in aquaculture	1995-1998	Fishfarmers & entrepreneurs Livestock farmers	• Package of practices for recycling of cellulose wastes and cattle refuse for aquaculture	ICAR	3.2
Microflora and quality of fish culture in sewage-fed waters with reference to shelflife and public health	on-going	fishfarmers & entrepreneurs	• Package of practices for fish culture with detailed account of microflora and public health standards	ICAR	5.6
Breeding, seed production and farming of groupers, rock cods and breams	1996-1998	Fishfarmers & entrepreneurs	• Increased seed production of marine fishes	CMFRI DBT ICAR	56.0
Hatchery production of Matrix	1995-1998	Fish farmers	• million seed production per year	CMFRI DBT ICAR	3.5
Hatchery production of green mussel	1995-1997	Mussel farmers Entrepreneurs	• Increased seed production of mussels	CMFRI DBT ICAR	14.0
Propagation of pearl oyster and pearl culture	1996-1998	Pearl farmers State Fisheries depts.	• Increased pearl production	CMFRI DOD ICAR	25.0
Tissue culture pearl oyster	1995-1998	Pearl entrepreneurs	• Increased pearl production	CMFRI DBT ICAR	4.25
Cultivation of Agar seaweeds in greenhouse	1995-1998	Agar industry Seaweed farmers	• Greenhouse technology for seaweed production	CMFRI DBT ICAR	4.85
On shore production of nucleated pearl oyster	1996-1999	Pearl farmers entrepreneurs	• lakh implanted oysters	CMFRI DBT ICAR	56.0
Commercial production of culture pearls adopting inshore culture technology	1996-1999	Pearl farmers & entrepreneurs	• production of 1.5 lakh cultured pearls	CMFRI ICAR	30.0
Polyculture of carps	1995-1997	Fishfarmers	• Increased fish production	Fish. Coll. DBT	2.1

Projects	Duration From/To	Target beneficiaries	Expected outputs	Implement'g organization	Budget (in lakh Rs)
Amino acid requirements of carps	1994-1997	Fishfarmers Fish researchers	• Increased yield of fish production	Fish Coll. IFS	4.02
Brood stock nutrition	1992-1997	Fishfarmers Hatchery managers	• Augmented fish seed production	Fish. Coll. Local Govt.	14.70
Cost effective feed formulation	1990-1997	Fish farmers Feed mill operators	• Development of economical feed	Fish Coll. IFS	4.20
Cryopreservation of mahseer sperms	1995-1998	Fish farmers State Fisheries depts.	• Availability of cryopreserved sperms	Fish. Coll. IFS	4.20
Hatchery production of M. rosenbergii	1996-1999	Prawn farmers & entrepreneurs	• Increased prawn seed production	Fish. Coll. ICAR	6.82
Monoclonal antibodies for Aeromonas	1993-1997	Fish farmers	• Development of rapid test kits for disease	Fish. Coll. DBT	18.9
Diagnostic kit for shrimps virus	1996-1999	Shrimp farmers	• Development of viral test kit	Fish Coll. MPEDA	5.0
Biofilm for oral vaccination	1993-1997	Fish farmers	• Development of oral fish vaccine	Fish. Coll. IFS	4.02
Ontogeny of immune system of carps	1993-1997	Fish culture industry	• Development of effective vaccine	Fish. Coll. IFS	4.02
Epizootic ulcerative syndrome	1995-1997	Fish farmers	• Development of medicine for EUS	Fish. Coll. ACIAR	4.2
Impact of parasites on reservoir fishes	1993-1996	Fishermen State fisheries depts.	• Development of host-parasite models	Fish. Coll. Karnataka Govt.	3.5
Development of hatchery technology for penaeid prawns	1987-1997	Prawn farmers State Fisheries depts. Shrimp farming industry	• Development of prawn hatchery technology	CIBA	27.0
Culture of penaeid prawns in different ecosystems	1989-1997	Prawn farmers State Fisheries depts.	• Development of prawn culture technology	CIBA	26.0
Culture of mud crabs	1992-1997	Fish farmers Crab farmers	• Development of technology for crab culture	CIBA	5.0
Brood stock development, breeding and seed production of brackishwater fishes	1988-1997	Fish farmers State Fisheries depts.	• Sufficient availability of brood stock and seed	CIBA	26.0
Culture of brackishwater finishes	1991-1997	Fish farmers State Fisheries depts.	• Improved culture technology of finishes	CIBA	38.0
Genetic selection for desirable traits	1995-1997	Fish farmers Hatchery managers State Fisheries depts.	• Development of genetically improved fish	CIBA	14.0
Diagnosis/prophylaxis and control of disease of prawn/ fishes	1990-1997	Fish farmers	• Development of medicines for control of diseases	CIBA	23.0
Development of feeds for	1988-1997	Fish farmers Feed	• Development of economical feeds	CIBA	38.0

Projects	Duration From/To	Target beneficiaries	Expected outputs	Implement'g organization	Budget (in lakh Rs)
aquaculture of brackishwater prawns and fishes		manufactures			
Soil and water quality and productivity management on shrimp farming	1995-1997	Shrimp farmers	• Development of soil-water management practices	CIBA	9.0
Design and development of machinery and structures for aquaculture	1991-1996	Fishfarmers State Fisheries depts.	• Development of aquaculture machinery	CIBA	13.5
Investigations on brackishwater aquaculture practices adopted by different categories of farmers	1992-1997	Fishfarmers	• Evaluation of degree of adoption of aquaculture technologies by farmers	CIBA	21.5
National Agricultural Research Project (NARP) IBRD on pond bioenergetics of prawn and fish	1992	Fishfarmers State Fisheries depts.	• Development of cost effective feed	ICAR CIBA	US$ 0.2m
Development of feed technology for semi-intensive/intensive prawn farming	1992	Shrimp farming industry Shrimp farmers	• Establishment of feedmill for economical feed production	ICAR CIBA	19.0
Broodstock development and seed production of seabass and groupers	1992	Fishermen Fishfarmers	• Development of induced breeding technique • Seed production in controlled conditions	CMFRI	20.0
Seed production, rearing and sea ranching of penaeid prawns	1984	Prawn farmers Fishermen	• Large scale seed production • Improved catches of marine prawns	CMFRI	10.36
Seed production and sea ranching of clams and pearl oysters	1989	Peal farmers Fishermen	• Increased production of pearl and oysters	CMFRI	17.75
Upgrading and transfer of technology of pearl oyster culture	1991	Pearl oyster farmers FIshfarmers	• Upgrading and extension of pearl culture	CMFRI	7.97
Feed development for culturable marine organisms	1995	Fishfarmers Feed industry	• Development of economical feed for mariculture	CMFRI	19.0
Breeding, seed production and ranching of sea cucumbers	1987	Fishfarmers Fishermen	• Increased seed production of cucumbers for sea ranching	CMFRI	2.7
Seaweed culture	1989	Seaweed farmers & industrialists	• Development of seaweed culture technology	CMFRI	5.0
Integration of small scale mariculture with small scale fisheries	1994	Fishfarmers	• Development of integrated mariculture technology	CMFRI	10.95
Breeding and culture of golden mahseer, *Tor putitora*	1991	Fishfarmers	• Augmented seed and fish production	NRCCF ICAR	8.0

Projects	Duration From/To	Target beneficiaries	Expected outputs	Implement'g organization	Budget (in lakh Rs)
Rearing of *Tor putitora* in cages in Central Himalaya	1996	Fishfarmers	• Increased fish production	NRCCF ICAR	3.0
Culture and breeding of Cyprinus carpio and other exotic carps	1994	Fishfarmers	• Increased fish and seed production	NRCCF ICAR	2.0
Breeding possibilities of schizothoracids	1996	Fishfarmers	• Improved availability of fish seed	NRCCF ICAR	2.0

VI. List of the Aquaculture Research Organizations Responding to this Survey

1. Indian Council of Agricultural Research
2. Central Institute of Freshwater Aquaculture
3. Central Institute of Brackishwater Aquaculture
4. Central Marine Fisheries Research Institute
5. National Research Centre for Coldwater Fisheries
6. Central Institute of Fisheries Technology
7. College of Fisheries, Mangalore

Indonesia

I. Background

Aquaculture is an important component of Indonesian fisheries which contributes to national food security, income and employment generation, and foreign exchange earning. Aquaculture production comprises 30% of the Indonesian fishery production. Aquaculture development has positive prospects in terms of reducing pressure on marine natural resources, creating job opportunities and as a source of livelihood. Recently, aquaculture development in Indonesia has accelerated and it is considered important in supporting rural economic development.

Aquaculture in Indonesia is divided into three main groups: freshwater culture, brackishwater culture and mariculture. In 1993 total aquaculture production was 600,384 tons from an aquaculture production area of 513,678 hectares. The aquaculture sector directly employed 1,969,356 people during the year. The export value of cultivated shrimp accounted for 61% of the total fisheries exports in 1993. Mariculture development is primarily geared towards alleviating adverse effects of declining fish stocks on the livelihood of small-scale fishing families and rural coastal communities.

II. National Aquaculture Development Plan

The Directorate General of Fisheries, Department of Agriculture is the agency responsible for planning and implementation of the national aquaculture development plan.

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

The current national development plan, REPELITA VI for the year 1994-1999, specifies the following objectives of the national aquaculture development plan.

Objectives of national aquaculture development plan	Priorities in aquaculture development plan
• To increase the quality of human life and incomes of fishfarmers by optimizing exploitation of natural resources through use of environmentally sound technologies, and increasing the added value of aquaculture products • To improve distribution and supply of quality fishery products • To generate employment opportunities • To support industrial growth by providing sufficient raw materials and increasing foreign exchange earnings.	• Intensification & refinement of brackishwater culture technologies and systems, and expansion of culture areas. • Improvement of freshwater culture technology, particularly development of stagnant pond culture, running water and backyard pond culture. • Development of marine finfish and shellfish culture • Increased seed production by artificial propagation

II. 2 Process followed in formulating the aquaculture development plans and priorities

Formulation of fisheries and aquaculture development policies and plans begins with the Broad National Guideline (GBHN) set by Parliament. The factors considered are the availability of resources, problems and constraints, lessons learned from previous policy implementation, macro-economic parameters set up by the National Planning (BAPPENAS). Inputs and feedback are also obtained form research institutions, universities, private sector,

fishfarmers, professional associations and other related government agencies and institutions.

To ensure the needs of all concerned parties are taken into account, the planning processes adopt "top-down" and "bottom-up" approaches. Top-down approach is applied to determine macro policies and objectives, while the bottom-up process is adopted to reflect local development needs and aspirations of fishfarmers.

The national policies are normally spelled out into the provincial and district policies. The development plan is divided into long-term (25 years), medium-term (5 years) and short-term (annual).

II. 3 Implementation of the National Aquaculture Development Plans

The strategy towards the development of national aquaculture is agribusiness-based. The policies adopted in the implementation of the fisheries subsector are:

- Strengthening functional linkages and inter-subsystems .
- Increasing rural economic activities.
- Improving partnership between large and small scale fisheries entrepreneurs.
- Developing aquaculture production centers in efficient and economic scale.

The Action plans for implementation are:

For new development:

- Expansion of culture areas through transmigration
- Expansion of culture units through provision of technological assistance
- Cooperation with the private sector, state-owned enterprise and cooperatives, particularly shrimp for brackishwater aquaculture; tilapia for freshwater aquaculture; and seaweed for mariculture

For established or existing aquaculture:

- Application or transfer of advanced technologies that promote sustainable aquaculture
- Development and enforcement of regulations and control of culture areas
- Diversification of cultured species
- Conservation and rehabilitation of culture areas

Changes and emerging issues resulting from implementation of the aquaculture development plan

No information was provided.

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspects	• Weak aquaculture development plan • Lack of presentation in decision-making and policy-planning • Lack of coordination among related agencies	• Lack of accurate data • Conflict of interest with other sectors • Lack of specific aquaculture program development in each agency involved	• Improve availability of data & information for planning • Policies & guidelines for use of land and water for aquaculture • Delineation of leadership role in each program • Establishment of regular linkages and contacts
Legal aspects	• Lack of regulation on zoning	• Conflict of interests with other sectors	• Legislation and guidelines for zoning
Information	• Lack of information exchange and sharing • Lack of appropriate information delivery methods and mechanism	• Unorganized data & difficulty in information retrieval	• Development of MISS
Human resources	• Lack of skilled personnel	• Lack of funds for HRD	• Identify funding agency
Technical aspects	• Difficulties in obtaining fish feed ingredients • Difficulties in obtaining artificial propagation • Difficulties in larval rearing • Pest and disease	• Lack of technology on fish feed production • Lack of hormones to stimulate spawning of fish • Lack of techniques on larval rearing • Viral and bacterial diseases	• Encourage research on fish nutrition and larval rearing • Multi-sectoral involvement, i.e., Department of Health • Initiate integrated treatment for viral and bacterial diseases
Physical and environmental aspects	• Pollution	• Industrial pollution	• Initiate waste management
Socio-economic aspects	• Poaching and theft at shrimp culture sites	• Social harassment; need for security	• Encourage security and reduce social harassment
Others	• High risk of aquaculture business	• Frequent aquaculture failure	• Establishment of pilot projects on specific aquaculture models

III. National Aquaculture Development Research

III. 1 Objectives and Priorities of the National Aquaculture Development Research

The main objectives of aquaculture research, which is guided by the Agency for Agricultural Research and Development (AARD), are to promote food self-sufficiency, diversification, income generation, employment growth, and export enhancement through:

- characterizing, evaluating, utilizing, and conserving of natural resources;
- generating and adopting technologies which can increase aquaculture productivity;
- developing sustainable aquaculture production system;
- providing efficient methods of processing, marketing and utilization of both food and non food products; and
- disseminating research findings to users, e.g., extension workers/farmers policy makers, scientist, and teachers.

Aquaculture Development Research Priorities

Priority research areas	Action plans & programmes	Expected outputs	Implement organiz.
Exploration, Inventory & management of fisheries resources	• Exploration - mainly underutilized areas • Strategies for development & utilization of resources • Conservation & rehabilitation	• New conventional & unconventional resources; zoning & management; Assessment of resource potentials • Data and information on species, abundance, characteristics, life cycle & population dynamics • Sustainable aquaculture development	RIMF
Aquaculture environmental management	• Oceanographic & limnological research • Diagnosis & prevention of ecological impacts of negative & excess culture and pollution	• Database • Ecosystem dynamics	RIMF RIFF RICF
Resource enhancement	• Research on zoning, habitat maintenance, seed supply, restocking & searanching • Resource enhancement through searanching	• Management of resources • Fishermen participation in resource enhancement • Appropriate management	RIMF RIFF RICF
Species inventory, characterization & evolution for culture	• Species identification & inventory • Collection & mapping genetic characteristics	• Basic information on superior species & their utilization • Basic information for protection of biodiversity & prevention of exploitation of germplasm	RIMF
Genetic improvement	• Study on population genetics • Genetic improvement • Transgenics		RIMF RIFF RICF
Fish biotechnologies	• Sees quality improvement • Organic matter bioconversion for feed • Biotechnology for fish disease control & prevention		RIMF RIFF RICF

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

The Central Research Institute for Fisheries (CRIFI) under AARD is one of the agencies responsible for planning and coordinating national aquaculture research sector. Other agencies such as the Study and Application Board for Technology (BPPT) and Indonesian Science Institute (LIPI) also plan and coordinate aquaculture research.

The aquaculture research priorities are derived from the policy directions and understanding of the broad research environment, capacities and mandates of the organizations. To further shape AARD's research into a "system", problem-solving research is carried out by the Directorate General of Fisheries, using policy oriented path and analytical path. In general, three categories research activities are undertaken:

- Immediate support to verify current program implementation and to develop short term alternatives
- Research to develop medium-term alternatives
- Pioneer and basic research to develop long-term alternatives

Priority consideration is on research concerned with those commodities and area that are of political, economic and social strategic importance; balanced growth and equity, and have potential to contribute to income and employment generation, particularly in the areas of resource endowment; and technological innovations.

The priority commodities identified in the master research plan of CRIFI are:

Freshwater commodities: Common carp, giant gouramy, pangasius, botia, arowana (*Scelopages formosus*), belida (*Notopterus* sp), freshwater prawn, clarias, sand goby , baung (*Macrones nemurus*), Nile tilapia, climbing perch.
Marine fish: big pelagic (tuna, skipjack), small pelagic (scad, mackerel, anchovy, squid), demersal fish (grouper, sea bass), shrimp (penaeids, lobster), and coral fish (napoleon fish).
Coastal aquaculture: milk fish, grouper, sea bass, shrimp, crabs, artemia, oyster, mussel, abalone, squid, seaweed, micro algae, trepang.

Process	Criteria used in setting priorities	Key participants
Current policy oriented path	• National development plan • Growth rate of commodities and provinces • Problems, needs & work plans determined by DGF • Potentials for cooperative actions with related sectors and agencies • Availability of fund, manpower and facilities	• Ministry of Agriculture • Directorate General of Fisheries (DGF) • Agency for Agricultural Research and Development (AARD) • Central Research Institute for Fisheries (CRIFI) - Coordinating centre for fisheries research • Institute for Assessment of Agriculture Technology
Analytical Path	• Importance to national economy, food security, employment, etc. • Market demands • Strategic importance for regional/provincial growth • Expected impacts of research on national economy, food security, employment, rural development, etc.	• Ministry of Agriculture • Directorate General of Fisheries (DGF) • Agency for Agricultural Research and Development (AARD) • Central Research Institute for Fisheries (CRIFI) - Coordinating centre for fisheries research • Institute for Assessment of Agriculture Technology
Monitoring & evaluation		• Research Unit & Central Research AARD, National Research Council, National Policy Agency and Ministry of Finance (for ex ante evaluation on planning) • Coordinated Review Teams (for monitoring research implementation) • Senior Scientist Sections (for ex post evaluation through review of research reports and coordinated workshop)

III. 3 National Aquaculture Research Capacity

List of main aquaculture research organizations and their affiliation

Name of key aquaculture research organizations	Institutional affiliation	Areas of competence
Directorate General of Fisheries	Min. of Agriculture	
Central Research Institute for Fisheries (CRIF)	Min. of Agriculture	
Research Institute for Marine Fisheries (RIMF)	Min. of Agriculture	
Research Institute for Freshwater Fisheries (RIFF)	Min. of Agriculture	
Research Institute for Coastal Fisheries (RICF)	Min. of Agriculture	
Marine Aquaculture Development Centre	Min. of Agriculture	
Freshwater Aquaculture Development Centre	Min. of Agriculture	
Brackishwater Aquaculture Development Centre	Min. of Agriculture	
Faculty of Fisheries, Brawijaya University	Min. of Education	
Faculty of Fisheries, Bogor Agriculture University	Min. of Education	
Faculty of Fisheries and Marine Science, Hasanuddin University	Min. of Education	
Faculty of Fisheries, Riau University	Min. of Education	
Faculty of Fisheries and Marine Science, Diponegoro University	Min. of Education	
Faculty of Fisheries, Pattimura University	Min. of Education	

The human resources of the aquaculture research institutions are considered to be adequate. However, most of the institutions have constraints relating to facilities, information exchange, coordination and collaboration, and disseminating research results.

Number of research personnel in aquaculture research institutions

Specialization	Ph. D.	M. Sc.	B. Sc.	Res. Assist.	Total
Biological Science	26	115	113	59	331
Physical & Engineering Sciences	4	26	8		38
Social Sciences		7	2		9
Economics	1	13	10		24
Legislation		2	1		3
Soil Science	1	1	1		3
Communication		1			1
Fish Processing	2	7			9
other		3	10		13
Total	34	175	145	59	431

III. 4 Programs of the Key Aquaculture Research Institutions

The research programmes of the key aquaculture research organizations are listed in the following table.

Names of Institutions	Main Research programmes	Priorities	Objectives
National Seafarming Development Centre, DGF	Breeding of marine finfish	seabass, grouper, red snapper	Seed production
	Breeding of other marine species	sea cucumber, pearl oyster, giant clam	Seed production
	Breeding of ornamental fishes	*Pomacanthus annularis*, sea horse	Seed production
	Fish nutrition & feed	feed formulation	Larva & broodstock diet
	Live food production	phytoplankton	chlorella, tetraselmis, dunaliela, rotifers, artemia
	Fish health and disease management	parasite, bacterial diseases	Fish health management and prevention and treatment of disease
Brackishwater Aquaculture, Development Centre, DGF	Fry production technique	milkfish, mud crab, shrimp	Improvement of breeding and seed production technologies
	Grow-out technologies	shrimp, mud crab, grouper	shrimp - circulation system mud crab - stocking density & fattening grouper - stocking density
	Pest & disease control	Histopathology Pest fishes microorganism	Diagnosis of fish disease pest control & elimination identification & control of microorganism
	Fish Nutrition & feed	natural food production artificial food production	production of phytoplankton & zooplankton artificial food production technologies
	Bioengineering	genetic improvement biotechnology aquaculture engineering	broodstock & quality seed microbial & vaccine production automatic control
	Bio remedy	management of pond soil & water	technologies for pond soil and water quality management

Names of Institutions	Main Research programmes	Priorities	Objectives
Research Centre for Coastal Fisheries, AARD	Fish nutrition	finfish crustacean	amino & fatty acid requirements
	Pathology	shrimp health management	factors affecting shrimp disease outbreak
	Aquaculture engineering	brackishwater pond management	rate of water recirculation
Research Institute for Freshwater Fisheries, AARD	Fisheries resource utilization and development	carrying capacity of lake for aquaculture Restoration of lakes/reservoirs	optimum utilization of lakes for cage culture improved water quality
	Breeding & genetic improvement	catfish genetics selection & hybridization of common carp genetic improvement of tilapia and giant prawn	improved catfish, common carp, tilapia and giant prawn
	Fish nutrition & feed	nutritional requirement of broodstock natural feed for larvae	feed formulation and nutritional requirement
	Fish health management	fish vaccination integrated fish disease control transgenic for disease control	Vaccination & prevention of fish diseases integrated disease control transgenic technology for disease control
	Aquaculture environment control	acute toxicity of herbicide toxicity of heavy metal	toxicity of herbicide on fish in rice field utilization of water body from coal mining
Slipi Research Station for Marine Fisheries, AARD	Microbiological & chemical safety of aquaculture products		Assessment of pollution causing health risk
	Bio-remedy for processing waste of aquaculture products		Improvement of environmental quality
	Depuration techniques for aquaculture products		improved consumer safety
	Processing of aquaculture products		value added products
	Handling of live fish		value added products
	Seaweed handling & processing		value added products
Faculty of Fisheries and Marine Science, Diponegoro University	Aquaculture		
Faculty of Fisheries, Brawijaya University	Bi-culture of tilapia -clarias	mass fry production production capacity bi-culture model	production of quality fry improved production technologies
	Brackishwater research	Disease control management technique	prevention of shrimp diseases improved production capacity
	Fish reproduction	Line purity of carps Reproduction cycles of river fish Clarias reproduction	keep good quality brood carp continuous availability of fry improved fry production

III. 5 Dissemination and Utilization of Research Outputs

As shown below, a variety of methods and medium is used to disseminate research findings.

Target Group	Methods
Policy planners, i.e., political level	Project reports & presentation; scientific publications; regional development meetings; symposium; seminars
Administrators & managers of government agencies	Project reports & presentation; On the spot visit; scientific publications; workshops; seminars; technical guidance
Fishfarming communities, small & medium scale industries	Research-extension linkage; on field research; training; demonstrations; field day & exhibition; on farm research; farmer meetings; community consultation; national agricultural consultation; workshop; action research
Private sector & supporting industries	Seminars; workshops; research collaboration; technical guidance; leaflets & brochure; action research
Research communities	Seminars; workshops; expo; scientific exchange; publications
Extension communities	Seminars; workshops; bulletin; on the job training; direct consultation; journals
Public at large	Field trial & consumer test; mass media; brochure; bulletin; journals

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research

The following table shows that the research organizations are faced with a variety of difficulties in formulating and implementing aquaculture research.

Category	Issues	Constraints	Required Actions
Administrative & institutional aspects	• Direction of research • Unified direction of research & development • Poor coordination & collaboration among related organizations	• Relevance of research • Weak linkage between research & extension	• Participation • Decentralized decision making • Improved linkage between related organizations & private sector
Legal aspects	• Policies for fishery development toward reliable agribusiness system	• Untested policies of using agribusiness approach	• Study of impacts and implication of policy instrument before and after implementation
Information	• Acceleration of technology transfer • Consistent application of 'participatory research appraisal' • Establishment of Assessment Institute for Agriculture Technology in province • Lack of information exchange • Poor utilization of research outputs • Lack of mechanisms & methods for disseminating research outputs	• Physical distance or remote location • Bureaucracy • Communication gap between technical personnel and extension specialists and users • Limited funds and facilities for information dissemination	• Improved communication between researchers and users, i.e., 1) communication through collaboration and networking and 2) scientific meetings, publications, on-farm research, use of visual materials • Increased funds for information exchange • Increased funds for participation in international scientific meetings • Improved information exchange system
Human Resources	• Insufficient human resource development • Heavy work load • Lack of skilled research personnel	• Lack of training opportunity	• Increased opportunities & budget for both degree and non-degree training • Improved morale and motivation for staff • Increased collaboration with international institutions
Research Facilities	• Inadequate research facilities	• Limited research funds	• Increased research funds & find finding sources • Reallocation of research facilities and equipment
Research	• Role and characterization of	• Lack of experience	• Strengthening of interagency and

Category	Issues	Constraints	Required Actions
environment	fisheries in national development • Planning for optimal and sustainable resource utilization and management • Interaction among researchers • Lack of farmer participation in research priority setting • Low priority to research • Low priority to postharvest technologies	• Lack of reliable and accurate data and information for planning • common property, open access, vulnerable resources	intersectoral coordination and cooperation • Planned production and alleviation of exploitation pressure on resources • Continued support for research • Make program development and budget allocation consistent with the mandates of organizations • Establishment of farmer organization • Training & involvement of fishfarmers

Comments in the shaded areas indicate those noted by the key research organizations, but not mentioned by the agency responsible for planning and coordination of national aquaculture research.

IV. List of on-going & Planned Projects of the Aquaculture Development Agency.

Project title	Duration	Objectives	Participating Organizations	
Development of disease-free *P. monodon* broodstock	1995		DOF	ASEAN
Harmonization of good shrimp management practices	1995		DOF	ASEAN
STD3 Work Programme - Assessment of tropical shrimp aquaculture impact on the environment using hydrobiology, ecology and remote sensing as using tools for diagnosis (Indonesia, Vietnam, New Caledonia)	1994-1996		DOF	EC

V. List of On-going & Planned Projects of Key Aquaculture Research Organizations.

Project title	Duration	Objectives	Research Organizations	
Investigation of mass mortality n shrimp culture in East Java	1997-99	To increase shrimp production	Brawijaya Univ	Wage-ningen Agri. Univ, Netherlands
Investigation of local carp line purity	1996-99	To identify pure line of local carp	Brawijaya Univ	
Bio remedial treatment o processing wastes of aquaculture products	1997-	To improve processing waste quality	Slipi Res. Station for Marine Fisheries	
Investigation on anti-microbial substances from seaweed	1997-	To reveal potential microbial activities of Indonesian seaweed	Slipi Res. Station for Marine Fisheries	
Fish Breeding & genetics	1996-2000	Improvement of fish genetics	RIFF	
Fish Pathology	1996-99	Integrated fish health management	RIFF	
Toxicology	1996-98	Toxicological aspects of domestic waste products	RIFF	
Ornamental fish breeding	1996-99	Breeding technologies for ornamental fish	RIFF	
Fish domestication	1996-2000	Domestication technologies for indigenous species	RIFF	
Standardization of fish seed quality	1996-98	Characterization of fish seed quality	RIFF	
Extraction of fish hypophysis	1996-98	Preservation technology of hypophysis	RIFF	
Fish biotechnology	1996-2001	Transgenic for fish disease prevention	RIFF	
Open water fisheries	1996-2000	optimum utilization of lakes for	RIFF	

Project title	Duration	Objectives	Research Organizations	
		aquaculture		
Catfish genetics	1996-98	Characterization & improvement of catfish genetics	RIFF	ECU
Fish pathology	1993-96	Prevention of EUS	RIFF	Australia
Shrimp pond waste treatment	1995-96	Efficient & effective waste treatment	Res. Inst. For coastal Fisheries	
Fish culture toxicology	1995-96	Distribution of pesticide residue	Res. Inst. For coastal Fisheries	
Polyculture & integrated farming	1995-96	Brackishwater pond productivity improvement	Res. Inst. For coastal Fisheries	
Squid reproduction	1995-96	model for squid hatchery	Res. Inst. For coastal Fisheries	
Fish & crustacean nutrition	1995-96	Development of feeds for coastal fish & crustacean	Res. Inst. For coastal Fisheries	
Shrimp health management	1996-97	Identification of factors affecting shrimp diseases	Res. Inst. For coastal Fisheries	
Feed quality improvement	1996-97	Study of amino acid requirements	Res. Inst. For coastal Fisheries	
Shrimp hatchery development technology		To develop simple & applicable hatchery technologies	Brackishwater Aqua. Dev. Cent.	
Shrimp seed production		Optimization of cost of shrimp seed production	Brackishwater Aqua. Dev. Cent.	
Mollusc reproduction system		To improve SR of seed	Brackishwater Aqua. Dev. Cent.	
Environmental and nutrition improvement of fry medium		Medium quality	Brackishwater Aqua. Dev. Cent.	
Shrimp pond construction improvement		specifications for shrimp pond construction	Brackishwater Aqua. Dev. Cent.	EEC
Grouper grow-out technologies		To improve growth at optimum cost	Brackishwater Aqua. Dev. Cent.	French
Environmental technology		To identify key factors on specific conditions	Brackishwater Aqua. Dev. Cent.	
Test, discussion & identification of remedies		To study environmental limits & tolerance	Brackishwater Aqua. Dev. Cent.	
Application of biotechnology to hatcheries & enzyme manipulation		To develop environmentally friendly tools and technologies	Brackishwater Aqua. Dev. Cent. Universities	
Broodstock quality improvement		specific morphology	Brackishwater Aqua. Dev. Cent. University	
Natural feed production for larvae		To improve SR on seed production	Brackishwater Aqua. Dev. Cent.	
Formulated diet application on grow-out system		Cost reduction and technology transfer	Brackish wat. Aqua. Dev. Cent.	
Brackishwater aquaculture development	1996-97	To establish sustainable brackishwater aquaculture industry	Brackishwater Aqua. Dev. Cent.	
Development & management of fisheries resources on ZEEI	1995-96	To improve available aquaculture technologies To provide solutions to technical problems in brackishwater aquaculture	Brackishwater Aqua. Dev. Cent.	
STD3 Work Programme on impact of shrimp aquaculture on the Indonesian environment	1995-97	to assess impacts of shrimp culture on coastal environment	Brackishwater Aqua. Dev. Cent.	EC

VI. List of the Research Organizations Responding to this Survey

1. National Seafarming Development Centre, DGF
2. Brackishwater Aquaculture Development Centre, DGF
3. Central Research Institute for Fisheries, AARD - Responsible for coordination of national fisheries and aquaculture research programs
4. Research Centre for Coastal Fisheries, AARD
5. Research Institute for Freshwater Fisheries, AARD
6. Slipi Research Station for Marine Fisheries, AARD
7. Faculty of Fisheries and Marine Science, Diponegoro University
8. Faculty of Fisheries, Brawijaya University

Islamic Republic of Iran

I. Background

Total aquaculture production in Iran was 46,271 tons in 1994. More than 10,000 people were directly employed in aquaculture in 1991.

After the Islamic Revolution, the Aquaculture Department accelerated its development of hatcheries to produce fingerlings for aquaculture units and for release into rivers. The development of aquaculture has been expanded to cover most of Iran's 25 provinces. Coastal aquaculture was recently introduced.

The success in mass production of fingerlings to replenish and enhance fish stocks in the Caspian Sea has led to the development of aquaculture and expansion of fisheries enhancement programs to other natural and man-made water bodies. This approach is aimed at (1) increasing the supply of cheap animal protein for the rapidly growing population and (2) improving the socio-economic status of the fishfarmers, fishermen and fisheries communities.

II. National Aquaculture Development Plan

The Iranian Fisheries Agency is responsible for planning and implementing the national aquaculture development plan.

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

Aquaculture Development Objectives	Aquaculture Development Priorities
• To provide employment	• Creation of employment opportunities
• To increase production, e.g., production of 110,000 tons by 1999	• Development aquaculture in rural areas
• To increase per capita consumption of aquaculture products	• Increase in protein supply and consumption

II. 2 Process followed in formulating the aquaculture development plans and priorities

SHILAT, working in cooperation with the provincial sectors and following the guidelines issued by the Committee for Water and Agriculture, prepares the national aquaculture development plan. The plan is negotiated with and approved by the Plan and Budget Organization (PBO). The current national aquaculture development plan is based on the broad goals of the Second Socio-Economic Development Plan, 1995-1999.

II. 3 Implementation of the National Aquaculture Development Plans

Important species cultured include shrimp, sturgeon, kutum, bream, pike, perch, Caspian carp, Caspian trout, *Aspius aspius*, barbus and roach.

Action plans and objectives of the national aquaculture development plan

Action plan	Objectives	Target beneficiaries	Expected results
Production of smolt for release to Caspian Sea	To increase harvest from the Caspian Sea.	• Fishermen	Well-being of fishermen
Aquaculture development	To conduct extension and pilot projects	• Farmers • Students • Training centers • Private sector (manufacturers)	
Construction of infrastructure in newly developed aquaculture sites aquaculture sites	To provide infrastructure for newly developed sites	• Planning authorities • Financial institutions (e.g. banks)	

Changes resulting from the implementation of the aquaculture development are improved welfare of fishermen, accelerated rural development and creation of employment opportunities.

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspects	• Lack of coordination • Delays in obtaining license, and construction of farms and hatcheries	• Complexity involved in management of the sector, and rapid development	• Regular meeting and consultation among related departments, agencies and sector
Legal aspects			
Information	• Ineffective technology transfer • Ineffective utilization of information • Inadequate access to and availability of information • Lack of information exchange and sharing • Lack of appropriate information delivery methods and mechanisms	• Weak aquaculture information centers in the country	• Develop the national aquaculture information capacities
Human resources	• Lack of expertise in such areas as fish health, fish nutrition, coldwater fish culture, shrimp hatchery techniques, integrated fishfarming		• Training and education opportunities
Technical aspects	• Lack of management guidelines in recycling of water and effluent treatment		• Development of management guidelines
Physical and environment aspects			
Socio-economic aspects			

III. National Aquaculture Development Research

III. 1 Role, Objectives and Priorities of the National Aquaculture Research

The Iranian Fisheries Research and Training Organization is the agency responsible for planning and implementing the national aquaculture research program.

The goals and objectives of the national aquaculture research sector are to:

- Conduct research on aquaculture biotechniques for native and economic fish species.
- Conduct research on increasing fishfarm productivity.
- Undertake research on searanching and inland aquaculture.
- Introduce new aquaculture methods.

Aquaculture research priorities and programs

Priority Research Areas	Research Programs	Expected output	Implementing Organization	Target beneficiaries	Date impl'td
Aquaculture biotechniques of native economic fish species	Finfish	To develop culture techniques for finfish	Khuzestan Center	Fishfarmers	1995-96
	Shellfish (shrimp)	To develop culture techniques for shrimp	Persian Gulf Center	Fishfarmers	1995-97
	Seaweed	To develop culture techniques for seaweed	Chahbahar Center	Fishfarmers	1997-99
Increasing aquaculture production	Warmwater fish species	To increase production to ten mt/ha	Guilan Center	Fishfarmers	1995-97
	Shrimp	To increase shrimp production to three mt/ha	Persian Gulf Center	Fishfarmers	1996-97
	Coldwater fish (trout)	To increase production of trout to 20 kg/m^3	Mazandaran Center	Fishfarmers	1997-99
Fish nutrition	Shellfish (shrimp)		Oman Sea Center (Bandar Abbas)	Fishfarmers	1996-97
	Coldwater fish (trout)		Mazandaran Center	Fishfarmers	1997-99
	Warmwater fish		Guilan Center		1997-99
Disease control and health management	Warmwater and coldwater fish species		Mazandaran, Khuzestan and Guilan Centers	Fishfarmers	1995-97
	Shellfish (shrimp)		Persian Gulf Center	Fishfarmers	1997-99
Searanching	Sturgeon fish (north)		Mazandaran and Guilan Centers	Fishfarmers	1995-99
	Finfish (north)		as above	Fishfarmers	1995-99
Genetics	Sturgeon fishes		Mazandaran and Guilan Centers	Fishfarmers	1995-97
	Finfish		Mazandaran, Khuzestan and Guilan Centers	Fishfarmers	1996-98
Cage or pen culture	Marine fish (cage or pen)		Khoozestan Center	Fishfarmers	1997-98
	Coldwater fish (cage)		Mazandaran Center	Fishfarmers	1997-99
	Sturgeon (pen)		Guilan and Mazandaran Centers	Fishfarmers	1998-99

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

The priority-setting exercise is initiated by experts in the various research centers. They identify the research areas. The Plans and Programs Department sets the priorities based on the viewpoints of the authorities and the availability of resources such as facilities, budget, manpower, structure. The plans are approved by the Research Council and the Board of Directors.

Type of organization	Process	Criteria	Participants
National aquaculture research coordinating agency, i.e., IFRTO	Consultative approach • Identification of research areas • Coordination with the appropriate organizations • Approval	• National development objectives • Executive requirements • Economic justifications • Availability of resources • Local development objectives (generation of employment)	• Experts (researchers) • Government agencies • Research Council • Board of Directors

III. 3 National Aquaculture Research Capacity

List of key aquaculture research organizations

Research organization	Affiliation	Area of competence
Iranian Fisheries Research and Training Organization (IFRTO)	Ministry of Jahad-e-sazandegi	
Guilan Fisheries Research Center (Anzali)	IFRTO	Sturgeon and finfish
Sturgeon Fishes Research Center Institute	Guilan Center	Sturgeon fishes
Astaneh Research Station	Guilan Center	Caspian bony fishes
Ghazian Research Station	Guilan Center	Warmwater fishes
Mazandaran Research Center	IFRTO	Sturgeon and finfish
Gharasou Research Center	Mazandaran Center	Sturgeon fishes
Kelardasht Research Station	Mazandaran Center	Coldwater fishes
Khuzestan Research Center (Ahvaz)	IFRTO	Finfish (marine and freshwater)
Mahshahr Research Station	Khuzestan Center	Marine finfish
Molla Sani Station	Khuzestan Center	Freshwater fishes
Persian Gulf Center	IFRTO	Shrimp
Sartol Station	Persian Gulf Center	Shrimp
Oman Sea Research Center (Bandar Abbas)	IFRTO	Marine finfish and oyster
Bandar Lengeh Station	Oman Sea Center	Oyster
Chahbahar Research Center	IFRTO	Seaweed

Number of research personnel of IFRTO

Fields	Total	Ph D	M Sc	B Sc	Technicians
DVM	9	9			
Biology	20		3	17	
Fisheries	33		3	11	19
Total	62	9	6	28	19

Adequacy of research capacity in meeting the national aquaculture development needs

National aquaculture development priority	Priority research needs	Adequacy*
Aquaculture research on native and economic fish species	• Technical aspects	3
	• Qualified manpower	3
	• Physical facilities	2
Increasing aquaculture production	• Technical aspects	4
	• Physical facilities	2
Fish nutrition	• Technical aspects	2
	• Fish feed ingredients	3
	• Pilot plan	1
Disease control and fish health management	• Technical aspects	2
	• Chemicals & other supplies	3
Searanching	• Technical aspects	4
Genetics	• Technical aspects	2
Cage or pen culture	• Technical aspects	2

* 1 - no capacity; 2 - inadequate; 3 - adequate; 4 - good; 5 - excellent

III. 4 Programmes of the Key Aquaculture Research Institutions

List of the programmes of the key aquaculture research organizations.

It was indicated that there exist 16 key aquaculture research organizations (see III.3) under the Iranian Fisheries Company or directly under the IFRTO. IFRTO responded to the survey.

III. 5 Dissemination and Utilization of Research Outputs

Target audience	Methods used
Policy planners, political level	Summary of final reports
Administrators and Managers of Government Agencies	Final reports
Fishfarming community, small and medium scale and community level	
Private sector and supporting industries. Including investment banks	
Research community	Final reports
Extension community	Final reports
Public	Final reports (in libraries)

III. 6 Issues and needs in planning and implementing national aquaculture development research

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Lack of coordination among related agencies		• Annual national coordinating meeting • Improve and facilitate coordination
Legal aspects			
Information	• Lack of appropriate delivery methods and mechanisms • Inadequate access to information	• Inadequate national information system • Lack of capability on networking	• Strengthen national information network • Staff training
Human resources and research competence	• Lack of skilled personnel • Difficulty in attracting and motivating aquaculture researchers	• Climate constraints in the south (hence difficulty to recruit personnel) • Lack of skilled personnel at local level • Very fast development of aquaculture in the country	• Local and foreign training of staff • Initiating specific courses in universities
Research facilities	• Inadequate equipment • Difficulty in obtaining supplies	• Difficulty in importation and exchange procedures	• Use research facilities of other organizations
Research environment	• Lack of linkage between research institutions and their clients		• Establishment of R&D department • Strengthen inputs of fishfarmers
Others	• Lack of regional projects	• Lack of coordination and collaboration with neighboring countries	• Develop cooperative regional projects

IV. List of On-Going Aquaculture Projects of the Aquaculture development agency

Project title	Duration from/to	Objectives	Target beneficiaries	Implementing organizations	Budget (Iran Rials)
Training of fish and shrimp farmers			Fishfarmers	Aquaculture Dept.	
Construction of training centers			Fishfarmers	Aquaculture Dept.	
Development of publications and training materials			Fishfarmers Students	Aquaculture Dept.	
Extension programs		To increase production		Aquaculture Dept.	
Artemia production		To increase production of artemia		Aquaculture Dept.	
Rehabilitation and enhancement of lakes and other water resources			Fishfarmers Fishing communities	Aquaculture Dept.	
Promotion of cage and pen culture through extension			Fishfarmers	Aquaculture Dept.	
Infrastructure development of shrimp and fish farms		To develop production capacity		Aquaculture Dept.	

V. List of On-Going Aquaculture Projects of key aquaculture research organizations

No information was provided.

VI. List of the Aquaculture Development Research Organizations Responding to this survey

IFRTO - Iranian Fisheries Research and Training Organization.

Malaysia

I. Background

Aquaculture makes an important contribution to protein food supply. Freshwater fish from aquaculture is particularly important in the rural hinterland areas where marine fish is generally not available. Total aquaculture production in 1995 amounted to 132,742 metric tonnes, valued at R.M.392.7 millions. The sector directly employs about 18,150 people.

The cultured species include cockle, mussel, oyster, shrimp, crab, grouper, seabass, milkfish, snapper, eel, red tilapia, carp, catfish, prawn, seaweed and ornamental fishes and plants. Nine major culture systems used are cockle culture in mud-flats; freshwater fish and prawn culture in ponds; freshwater fish culture in floating net-cages; brackishwater culture of shrimps and marine fish in ponds; marine fish culture in floating net-cages; mussel culture in rafts and poles; oyster culture in rafts and racks; crab culture in cages and ponds; aquarium fish breeding and culture in tanks and ponds.

The main thrust areas identified under the Aquaculture Development Action Plan for 1996-2010 are shrimp farming, cage culture in freshwater as well as the open sea, and tank and raceway culture. Development of new culture areas such as the open sea and marginal agricultural lands, utilization of new species for culture and increase in productivity will receive greater emphasis. The expected production by 2010 is 340,000 metric tonnes.

Research inputs are needed in many areas, particularly in seed production of marine fin fishes, fish nutrition and feed formulation, and fish health management. Additionally, fiscal incentives to boost the industry and legislative measures are required to ensure sustainable development and safeguard the interests of the aquaculture industry.

II. National Aquaculture Development Plan[4]

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

The National Agriculture Policy (1992-2010) outlines the importance of aquaculture as an alternative means of increasing fish production. In achieving this objective, the strategies specified under the Seventh Malaysian Plan (1996-2000) include:

- Encourage commercial aquaculture production and large-scale cage-rearing in the seas
- Intensify R&D efforts, particularly in the down stream activities to enhance the agro-based industry and to produce more high quality end-products;
- Optimize land, water and other resource usage; and
- Minimize ecological damage and impacts.

The major areas of development outlined in the Aquaculture Development Action Plan (1996-2010) are:

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[4] The agency responsible for planning and development of the aquaculture sector did not participated in the survey. Information presented in this section is from other sources such as the national papers presented at the NACA Technical Advisory Committee meetings in 1992 and 1996 and the Conference on Fisheries Management and Development Strategies for the ASEAN Region for the Year 2000 held in 1994; the findings of the BOBC Subcommittee mission of 1993; "Aquaculture in Malaysia" by I. A. Kechik (in: Bagarinao, T. U. and E. Flores (eds.). Towards Sustainable Aquaculture in southeast Asia and Japan. SEAFDEC/AQD, Iloilo, Philippines. Pp125-135.); and "The status and perspectives of the aquaculture industry in Malaysia" by I. A. Kechik (unpublished manuscript).

- Traditional practices using ponds, mining pools, cages and cement tanks with effluent treatment systems
- Intensified circulating system with minimum land use but maximum yield
- Integrated aquaculture-agriculture culture scheme and self sufficiency which incorporates raceways, greenhouse, hatchery, breeding, processing and feed mill
- A factory concept of culture for ornamental fish
- Searanching using rigid frame cage structure and submersible spar buoy cage
- Aquaculture platform in the sea, with submersible platform which incorporate mollusc culture and "rotatable" net-cage culture

In addition, special efforts are being made to identify and develop "industrial aquaculture development areas", and to prepare and implement guidelines and regulations necessary for sustainable development of aquaculture.

II. 2 Process followed in formulating aquaculture development plans and priorities

The Department of Fisheries is responsible for formulation and implementation of national aquaculture development action plan.

II. 3 Implementation of the National Aquaculture Development Plans

The strategies for implementing the national aquaculture development plans includes:

- development of new and non-conventional culture sites, e.g., man-made water bodies, open seas, brackishwater ponds, use of zoning concepts
- new culture systems
- new culture species and genetic improvement of cultured species
- increased productivity through refinement of culture technologies, particularly for marine finfish, oyster, crab, shrimp, improved feeds, biomanipulation of ponds, mechanization of fish farms, improved postharvest handling, and product development.

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

- Inadequate supplies of seeds and feeds, particularly for marine fishes
- Fish health management
- Judicious and coordinated planning and management
- Strong institutional support, e.g., R&D, information dissemination, technology transfer, human resource development
- Attractive credits and incentive scheme
- Guidelines and regulations for resource use, e.g., zonation, and environmental management
- Product development and marketing

III. National Aquaculture Development Research

The agency responsible for planning and implementation of the national aquaculture research sector is the Fisheries Research Institute (FRI) of the Department of Fisheries.

III. 1 Role, Objectives and Priorities of the National Aquaculture Research

The main function of the national aquaculture research sector is to carry out research on all aspects of living aquatic resources exploitation and management, including aquaculture. The aquaculture research sector facilitates the development of the aquaculture industry through the provision of technical support, and enhances fish production through the development of appropriate culture and propagation technologies and utilization of new species for culture.

The role of research organizations is to undertake research on aspects pertaining to aquaculture, particularly on the development, refinement and adaptation of appropriate technologies and utilization of new species for culture. They are also partly responsible for the dissemination of new knowledge and techniques in aquaculture.

National aquaculture development research priorities

- Development and refinement of hatchery and grow-out technology
- Fish nutrition and feed formulation
- Fish health management
- Effluent management

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

Type of organization	Process	Criteria	Participants
Research organization	• Participatory process (in-house brainstorming sessions) • Consultative (discussions with other research institutions) • Approval by Agro-Industry panel of IRPA, Ministry of Science and Technology	• National development needs and priorities • Industry analysis • Capability analysis • Research competence of the organization	• Researchers (government and universities) • Other government agencies • Industry • Agro-Industrial Panel of the Ministry of Science and Technology

III. 3 National Aquaculture Research Capacity

List of main aquaculture research organizations

Main aquaculture research organization	Institutional affiliation	Area of competence
Fisheries Research Institute	Ministry of Agriculture	• Hatchery and growout technology for fish, prawn, mollusc • Fish diseases
Universiti Sains Malaysia	Ministry of Education	• Fish diseases • Nutrition • Fish culture technology
Universiti Pertanian Malaysia	Ministry of Education	• Fish diseases • Nutrition • Hatchery and culture technologies for prawn
Universiti Malaya	Ministry of Education	• Fish genetics
Universiti Kebangsaan Malaysia	Ministry of Education	
IPP, Bintawa	Ministry of Agriculture	• Culture technology
Fisheries Department, Sabah	Ministry of Agriculture, Sabah	
Department of Agriculture, Inland Fisheries Section	Ministry of Agriculture and Community Development, Sarawak	

Adequacy of research capacity in meeting the national aquaculture development needs

No information was provided.

III. 4 Programmes of the Key Aquaculture Research Institutions

List of the programmes of the Fisheries Research Institution, Department of Fisheries Malaysia

Priority research areas	Objectives	Date imp.
Development and refinement of hatchery technology		
Propagation of commercially important marine finfish	To propagate grouper by artificial means using cryopreserved gametes	1996-97
Propagation of indigenous freshwater fish	Artificial propagation and fry production techniques for various species	1996-98
Propagation of marine shrimp	Enhanced eye stalk ablated spawners; reutilization of spawners	1996-98
Propagation of sea cucumber	Commercial production-commercial propagation and hatchery production of sea cucumber	1996-98
Crab seed production	Commercial production of crab seed in hatchery	1996-98
Biology, breeding and culture of cephalopods	Commercial propagation and culture of cephalopods	1996-98
Development and refinement of grow-out technology		
Development and refinement of open sea cage culture systems	Development of suitable open sea cage design and identification of suitable fish species	1996-98
Refinement of culture techniques for commercially attractive molluscs (e.g. oyster, abalone, cockles)	To study cockles in deeper water; to study sustainable shrimp farming	1996-98
Alternative use of shrimp ponds for sustainable aquaculture	To develop suitable shrimp culture techniques	1996-98
Factors influencing the remote setting of tropical oyster larvae	Commercial oyster spat production	1996-97
Development of pond management strategies for the economic production of white/banana shrimp	Development of suitable culture techniques for white shrimp	1996-98
Refinement of polyculture system involving marine shrimp/fish/seaweed/molluscs	Development of suitable techniques for seaweed culture in ponds	1996-98
Development of recirculating water system for fish culture	Development of viable recirculating water system for commercial fish culture in tanks	1996-98
Nutrition and feed formulation		
Identification and development of mass production techniques for phyto and zooplankton suitable as larval feed for cultured marine finfish	Identification of suitable substitutes for artemia as live feed for fish/shrimp larvae	1996-98
Fish health management		
Immunoassay for the detection of *Aeromonas hydrophilla* from fish and aquatic environment	Development of rapid diagnostic kits	1996-98

Number of FRI research personnel by area of specialization

Specialization	PhD	MSc	BSc	Res. Assist.	Total
Biological sciences		1	13		14
Physical and engineering sciences			2		2
Environmental science			1		1
Chemistry/biochemistry			2		2
Fisheries		1	6		7
Others		7		1 (vet med.)	8
Total		9	24	1	34

III. 5 Dissemination and Utilization of Research Outputs

Target groups	Methods used to transfer research outputs
Policy planners; Political level	Research reports; Briefing sessions
Administrators & Managers of government agencies	Research reports; Seminars; Publications
Fishfarming community	Extension publications; Manuals (formal and informal); Training Direct consultation
Private sector and supporting industries	Publications; Direct consultations; Seminars
Research community	Scientific publications; Seminars and other fora
Extension community	Training; Extension publications; Seminars and workshops
Public in general	Publications, radio and TV; Seminars; Direct consultations

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Development Research

Category	Issues	Constraints	Required Action
Administrative and institutional aspects	• Poor coordination in priority-setting and research management • Weak interagency linkage	• Lack of coordination • Lack of coordinated priority setting, e.g., planning by Ministry of Agriculture (MOA) and approval of funding by Ministry of Science, Technology and Environment (MOSTE)	• Coordination between MOA and MOSTE
Legal aspects	• Intellectual property rights	• Lack of patents	• Improved legislation
Information	• Lack of exchange and sharing • Ineffective utilization of information	• Poor library set-up • Lack of funding • Need to develop proper attitude towards information • Lack of exposure to international conferences	• Strengthen libraries and information programs • Establish linkages with information networks • Initiate more aggressive efforts to publish research results • Encourage participation in international conferences
Human resources and research competence	• Lack of skilled personnel in nutrition, diseases, genetics • Lack of skilled human resources (critical mass)	• Weak programs for human resources development • Lack of interest in postgraduate training • Research hindered by administrative work	• Institute more aggressive HRD program for postgraduate training, with funding from the government
Research facilities			
Research environment	• Little dialogue between research institutions and their clients • Lack of collaborative research effort • Low priority given to research	• Lack of collaborative attitude • Ad hoc and short-term research planning • Weakness in organizational structure • Lack of research guidelines	• Revise organizational structure based on team approach • Long-term planning • Promote collaborative and participatory approach • Establish a centralized organization for aquaculture research

Urgent aquaculture development and research needs that are not addressed by existing programs and projects are:

- Feed development and disease
- Development of standards and legislation for sustainable aquaculture practices and quarantine introduction
- Shrimp viral diseases
- Molecular genetics for regional stock improvement
- Development of sustainable aquaculture technologies/practices

IV. List of On-Going Aquaculture Projects of Aquaculture Development Agency

No information was provided.

V. List of On-Going Aquaculture Development Research Projects of Fisheries Research Institute

Title of Projects	Duration from/to	Target beneficiary	Expected output	Particip at'g organiz.	Budget (RM)
Cryopreservation of marine finfish gametes	1996-97	Fishfarmers	• Development of techniques for the cryo-preservation storage of marine finfish gametes from selectively bred fish for use in future crosses	FRI	174,000
Breeding and mass fry production of *Channa striatus*	1996-97	Fishfarmers	• Breeding and larval rearing techniques of *Channa striatus*	FRI	101,500
Broodstock management of freshwater fish	1996-98	Fishfarmers	• Establishment of management techniques of broodstock of freshwater fish in tanks and cages	FRI	105,156
Enhancement of induced maturation of eyestalk ablated tiger shrimp adults wit biochemical and environmental factors	1996-98	Fishfarmers	• Determination of suitable feeds and environmental factors which could increase the frequency of maturation and improve the quality of spawning of the eyestalk ablated tiger shrimp adult broodstock	FRI	205,500
Studies on reproductive biology, artificial propagation and commercial production of sea cucumber juvenile	1996-98	Fishermen Processors	• Reproductive cycles of commercial sea cucumber in Malaysian water • Production of juvenile sea cucumber in the hatchery from wild and culture broodstock	FRY	181,000
Crab seed production	1996-98	Small-scale farmers	• Increased survival rates of the crab larviculture for mudcrab and blue swimming crab • Production of crab seeds for pond growout	FRI	88,760
Biology, breeding and culture of Cephalopoda in hatchery	1996-98	Fishermen	• Biology information and guide for future breeding of commercially important group of cephalopods • Identification of risks and problems related to the breeding aspect	FRI	74,760

Title of Projects	Duration from/to	Target beneficiary	Expected output	Particip at'g organiz.	Budget (RM)
Induced breeding of indigenous freshwater carp	1996-98	Hatcheries (commercial and farm level)	• Induced breeding techniques for the propagation of the indigenous freshwater carp using hormones/drugs as induction agent • Development of viable larval rearing and nursing techniques for the mass propagation of fish fry	FRY	157,500
Development and refinement of open sea cage culture system	1996-98	Fish farmers Cage farmers Entrepreneurs	• Suitable and cost-effective cage materials and design • Suitable finfish species for open sea cage culture • Economically viable cage management techniques • Development of a carrying capacity model for cage culture in marine environment	FRI	317,750
Culture of cockle in deeper waters	1996-98	Cockle culturists	• Determination of the viability of culturing cockle in deeper waters beyond existing inter-tidal mudflats • Suitability of using new fishing gear for harvesting of cockles	FRI	133,000
Sustainable shrimp farming of tiger shrimp	1996-98	Pond culturists	• Development of pond and water quality management protocols for intensive and sustainable pond culture of tiger shrimp via biomanipulation approach	FRI	283,000
Alternative use of shrimp ponds for sustainable aquaculture	1996-98	Shrimp farmers	• Alternative uses for shrimp ponds to reduce incidence of disease infestation, following continuous shrimp culture • Ensured sustainability of shrimp culture through crop rotation	FRI	152,500
Factors influencing he remote setting of the tropical oyster larvae	1996-98	Fisherfolk	• Determination of factors conducive to the remote setting of oyster larvae	FRI	140,000
Development of pond management strategies for the economic production of white/banana shrimp	1996-98	Fish farmers	• Development of a method for pond culture of white/banana shrimp at nursery phase and grow-out phase with the primary objective of attaining economic production of shrimp	FRI	106,500
Seaweed culture-open water and pond culture of Gracilaria	1996-98	Inshore fisherfolk Fish farmers	• Confirmation of the taxonomic classification of the cultured potential species • Determination of the suitability of cultivation of Gracilaria in open water and in ponds. • Determination of the parameters influencing yields of agar and its quantity	FRI	280,000
Development of filter system in fish culture in tanks	1996-98	Fish farmers	• Culture techniques of Temoleh in ponds	FRI	151,000

Title of Projects	Duration from/to	Target beneficiary	Expected output	Particip at'g organiz.	Budget (RM)
Development of cage culture technology using an improved cage design utilizing indigenous fish species *P. bulu* and *M. memurus* and its impact on the environment	1996-98	Aquaculturists Fish cage culturists	• Cage culture technology for indigenous freshwater dish species utilizing a new cage design	FRI	180,000
Towards minimizing artemia usage in marine shrimp larviculture	1996-98	Farmers Feed producers	• Determination of the maximum amount of artemia that could be replaced by formulated feeds for marine shrimp larvi culture • Determination of the appropriate stage of larval [development] which could receive maximum amount of formulated feed to replace artemia	FRI	81,360
A rapid and simplified immunoassay for selection of a Hydrophila from fish, water and aquatic environment	1996-98	Fish farmers	• Simple immunoassay for rapid detection of he pathogen from cultured freshwater fish, rivers, lakes, fishponds and from different drinking water supply	FRI	307,000
Selection of body conformation and high fillet weight in the red tilapia hybrid	1996-98	Large scale farms Small holders	• A strain of red tilapia hybrid with a small head, deep body and high fillet weight	FRI	92,100
Breeding of Arowana, *Scleropages formosus*	1996-98		• Determination of some aspects of reproductive biology and ecology of marine turtles	FRI	308,000

VI. List of the research organizations responding to this survey

1. Fisheries Research Institute

Nepal

I. Background

Aquaculture is a small but potentially important sector, and can play a significant role in enhancing livelihood in rural communities. In 1995, total production was 11,985 tons from a production area of 5,466 ha. Contribution of aquaculture sector to GNP was 0.8% valued at 13,962 million Rupees (Rs). It was estimated that approximately 220,000 persons were directly employed in aquaculture and fisheries sector.

II. National Aquaculture Development Plan

The Fisheries Development Division of the Department of Agriculture is responsible for the planning and implementation of the national aquaculture development plan.

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

Aquaculture Development Objectives	Aquaculture Development Priorities
• To increase fish production • To generate rural employment and income • To utilize natural resources rationally for fish production	• Polyculture of carp in ponds • Utilization of larger water bodies in aquaculture • Cage and pen fish culture • Integrated fish farming

II. 2 Process followed in formulating the aquaculture development plans and priorities

Processes	Criteria	Participants
Consultative process in the form of annual workshops at three levels: • district • regional • national	• Potential of aquaculture • Farmers' needs • Availability of resources • Availability of technology	• District aquaculture extension officers • Fisheries Resources Centres • National fisheries officers • Planning officials (agriculture, finance, planning) • Fishfarmers

II. 3 Implementation of the National Aquaculture Development Plans

The strategies of the National Aquaculture Development Plan are:

- To ensure reliable supply of fish seed through the Government Fish Hatchery as well as private sector hatcheries;
- To utilize existing village ponds and other wet lands that are appropriate for aquaculture;
- To promote integrated fish farming, including paddy cum fish culture systems
- To promote private sector hatcheries and nurseries;
- To promote cage culture, enclosure fish culture and open water aquaculture;
- To introduce large-sized fingerlings in polyculture to achieve high yield;
- To disseminate appropriate technology to farmers through aquaculture extension offices and fisheries resource centres.

Presently, seven species of commercially valuable carps are cultured in Nepal. These include three indigenous (rohu, naini and bhakur) and four exotic (common carp, silver carp, bighead carp and grass carp) species. Attempts are being made to culture exotic high-value rainbow trout (*Oncorhynchus mykiss*) in raceways or cement tanks, Sahar (*Tor putitora*), katle (*Neolissochilus hexagonolepis*) and asala (*Schizothorax spp.*), tilapia (*Oreochromis nilotica*), silver barb (*Puntius gonionotus*) and the giant fresh water prawn (*Macrobrachium rosenbergii*) in the plains.

Action plans and objectives of the national aquaculture development plan

Action plans	Objectives	Target beneficiaries	Expected results
Demonstration and outreach	To transfer fish farming [technologies] to the private sector	Fishfarmers	Availability of verified technology for transfer to farmers
Fish seed production	To produce high quality fish seed	Fishfarmers	Optimum use of culturable areas and better production
Manpower development	To train farmers and fishery technicians	Fishfarmers	Better management of fishfarms and use of improved techniques
Technology verification	To increase production	Fishfarmers	Greater domestic supply of fish

Changes and emerging issues resulting from implementation of the aquaculture development plan

Action plans	Changes or effects	Issues	Actions required
Demonstration and outreach	Motivated private sector	Inability to reach the small-scale farmers	Make extension services more effective
Fish seed production	Increase in fish seed production	High mortality in fish seeds	Introduce large sized fingerling in polyculture
Manpower development	Improvement in fish farm management	Existing gap between public and private sectors	Undertake mass training on technologies
Technology verification	Increased production per unit area	Technology transfer	Make extension services more effective

II. 5 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspects	• Lack of support • Inadequate development plan • Lack of coordination	• Lack of representation at decision-making level	• Creation of a fisheries and aquaculture department with a clear mandate • Master plan for fishery and aquaculture
Legal	• Inadequate regulation for water utilization and effluent management	• Lack of regulation	• Clear laws and by-laws for water utilization
Information	• Ineffective technology transfer • Lack of information delivery methods and mechanisms • Ineffective communication between public & private sectors, and agencies at different levels	• Ineffective extension system	• Give priority to aquaculture extension
Human resources	• Lack of skilled manpower in fish disease , limnology and economics	• Lack of human resources planning	• Plan for HRD

Category	Issues	Constraints	Required actions
Technical	• Lack of guidelines on effluent treatment	• No law for water protection	• Legislation and enforcement
Physical and environment	• Water pollution	• Lack of appropriate law	• establishment and enforcement of legislation
Socio-economic aspects	• Difficulty in obtaining credits • Poor marketing skills • Postharvest handling & processing	• High interest rates • Lack of farm roads, i.e., transportation difficulties • lack of cold storage and high spoilage during transportation	• Coordination between extension and credit • Strengthen farmers' marketing skills • Attention to post harvest sector

III. National Aquaculture Development Research

III. 1 Role, Objectives and Priorities of the National Aquaculture Research Functions and role

The objectives of the national aquaculture development research sector are to:

- Develop advanced and appropriate technologies for increasing productivity;
- Develop suitable techniques for rational utilization of natural resources to increase high-quality animal protein.

The priority research areas are:

Priority Research Areas	Research Programs	Expected outputs	Implement-ing Organiz.	Target beneficia-ies	Date imp.
Cage fish culture	• Culture techniques of planktivorous carps in cages • Culture of common carp with feed in cages	• Increase in fish production	Nepal Agriculture Research Council (NARC)	Fisheries sector	1991
Genetic upgrading of broodstock	• Genetic study of Indian major carps in wild and hatchery condition	• High productivity	NARC	Farmers	1994
Pond fish culture	• Polyculture of carp with feed and fertilizers • Improved quality & quantity of fish seed production • Fish health management • Water quality management • Fish nutrition & feed formulation	• Increased fish productivity	NARC	Farmers	1991
Production technology	• Culture technology of trout in raceway • Breeding techniques of indigenous fish	• Increased fish productivity	NARC	Entrepre-neurs Farmers	1991
Use of large water bodies	• Biological & limnological studies of major river systems & assessment of productivity • Socio-economic impacts of river systems on population • Breeding & propagation technologies for economically important Trans-Himalayan fish species • Cage & enclosure fish culture,				

Priority Research Areas	Research Programs	Expected outputs	Implement-ing Organiz.	Target beneficia-ies	Date imp.
	stocking density & feed ratios • Commercial production of high-value fish, e.g., rainbow trout				

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

Type of organization	Process	Criteria	Participants
Nepal Agriculture Research Council (Fisheries Research Division)	• Problems are identified by extension agents • The identified problems are reported to the Fisheries Division of the Department of Agriculture	• Perceived problems of fishfarmers • Production increment resulting from the use of appropriate technologies	• National agencies concerned with aquaculture, such as the Fisheries Development Division; Fisheries Research Division; Fisheries Development Centres; Fisheries Research Centres • Aquaculture extension offices

The Fisheries Research Division of the Nepal Agriculture Research Council is responsible for the planning and coordination of the national fisheries and aquaculture research policies and programs. The Fisheries Research Division in coordination with the Fisheries Development Division initiates the identification of problems. A Research Panel sets the priorities of aquaculture research.

III. 3 National Aquaculture Research Capacity

List of key aquaculture research organizations

Research organization	Affiliation	Area of competence
Godawary Fisheries Research Center	Department of Agriculture	Coldwater aquaculture
Trisuli Fisheries Research Center	Department of Agriculture	Riverine aquaculture
Pokhara Fisheries Research Center	Department of Agriculture	Lake and reservoir aquaculture
Parwanipur Fisheries Research Center	Department of Agriculture	Warmwater pond fish culture
Tarhara Fisheries Research Center	Department of Agriculture	Carp culture
Aquaculture and Fisheries Department Institute of Agriculture and Animal Science, Tribhuvan University,	Department of Education	Carp culture
Department of Zoology, Tribhuvan University,	Department of Education	Taxonomy; Fish ecology Environment impact assessment

Adequacy of research capacity in meeting the national aquaculture development needs

Aquaculture development priorities	Priority research needs	Adequacy*
Aquaculture technology	• Fish breeding	4
	• Fish seed rearing & nursing	3
	• Intensive polyculture	3
	• Disease control	2
Cage fish culture	• Planktivorous carp culture	4
	• Common carp culture with feed	2
Genetic upgrading of broodstock	• Assessment of differences between wild carps and hatchery carps	1
High value fish production	• Raceway culture of trout	3
	• Breeding of native fish	3
	• Raceway culture of native fish	2

* 1 - no capacity; 2 - inadequate; 3 - adequate; 4 - good; 5 - excellent

III. 4 Programs of the Key Aquaculture Research Institutions (from the national report)

Programmes of Aquaculture Research by Research Centres for year (1996/97):

Fisheries Research Division, Godawari

1. Stocking density of yearlings in polyculture fish farming
2. Density and feeding management in fish larviculture in pond
3. Biological study of major river systems of Nepal
4. Cultivation of free breeding Nile tilapia with predator fish species
5. Performance of Common carp in rice fish system in Chitwan
6. Projects on walking catfish in pond condition in Nepal
7. Study on the growth of Common carp with plant protein sources
8. Survey of the epidemic bacterial disease on cultured fish in different water bodies
9. Residue detection of chemicals in fish flesh
10. Studies on microbial fauna of intensive fish culture in relation to the environment
11. Brood conditioning factors for the multiple breeding of carp
12. Fish germplasm & museum specimen collection & their taxonomic study
13. Effects of light on the spawning of trout
14. On the growth of trout under different environmental condition
15. Histopathological studies in trout
16. Carp seed production
17. Production of marketable trout

Fisheries Research Centre, Pokhara

1. Study on growth of planktivorous fish fry in the lakes of Pokhara
2. Growth of common carp in floating cage in lake, with feeding
3. Replacement of animal protein by plant protein in supplementary fish diet
4. Feed development for larvae & fry of Mahseer and carp
5. Zoo-phytoplankton culture in nursery ponds
6. Breeding of Mahseer & study on the possibility for mass production
7. Limnological effects on the growth of caged fish in the lakes of Pokhara Valley

8. Post-spawning brood management of silver carp
9. Development of fermented soybean for the replacement of fish meal in fish diet
10. Standardization of nutritional level & energy value of fish feed ingredients to develop different fish diets; fish feed quality control
11. Production of fish seed
12. Production of table fish
13. Farmers participation

Fisheries Research Centre, Trishuli

1. Survey of trout culture site
2. Determination of optimum stocking density of rainbow trout
3. Rearing of sahar fry to advanced size fingerling
4. Productivity assessment of a part of Trishuli river
5. Partial replacement of shrimp feed with soybean & extruded soybean
6. Comparative study hatchability and abnormality of alevins resulting from rainbow trout broodstock feeding on two types of food
7. Production of table fish
8. Fish seed production

Fisheries Research Centre, Tarahara

1. Performance of common carp in rice - fish system in Tarahara
2. Stocking density of yearling on the productivity of polyculture fish farming system
3. Production of carp seed & table fish

Fisheries Research Centre, Parwanipur

1. Identification of mortality factors during fingerling transportation from hilly region to plains
2. Production of carp seed

Number of research personnel by area of specialization (from the national report)

Institutes	No. of scientists	Technical officers	Administration & other	Tota l
Fisheries Research Division	1	1	2	4
Fisheries Research Centre, Pokhara	2	7	50	59
Fisheries Research Centre, Godawari	2	3	17	22
Fisheries Research Centre, Trishuli	1	3	21	25
Fisheries Research Centre, Parwanipur	-	1	10	11
Fisheries Research Centre, Tarahara	-	3	8	11
Total	6	18	108	132

III. 5 Dissemination and Utilization of Research Outputs

Target audience	Methods used
Policy planners	
Administrators and managers	
Private sector and supporting industries	
Fishfarming community	Outreach demonstrations in farmers' fields
Research community	Technical symposium/ workshop
Extension community	Through the district agricultural office
Public in general	

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research

Category	Issues	Constraints	Required Action
Administrative and institutional aspects	• Low priority given to aquaculture research	• Lack of representation at decision-making level. • Weak capacity of the Nepal Agriculture Research Council	• Strengthening research planning & management capacity of the central agency
Legal aspects			
Information	• Ineffective technology transfer • Insufficient information flow between researchers and research institutes • Lack of library services	• Inefficient aquaculture extension	• Strengthen aquaculture extension system
Human resources and research competence	• Lack of skilled personnel in pond culture • Weak capacity in research planning & management	• Inability of newly established Nepal Agriculture Research Council to recruit competent personnel	• Provide opportunities for advanced studies
Research facilities	• Inadequate research facilities	• Physical facilities not appropriately designed and located	• Develop research facilities
Research environment	• Little dialogue between institutions and their clients • Lack of incentives • Well planned research policy & programmes • Lack of social scientists • Lack of international linkages	• Inadequate capacity to solve [aquaculture] problems	• More efforts to identify real problems of clientele (by research institutions)

IV. List of On-Going Projects of the Aquaculture development agency

Project	Duration From/To	Target beneficiaries	Objectives	Implementing organiz.	Budget (Nepal rupees)
Projects at the Fisheries Development Centre (FDC), Geta	Regular activity	Fishfarmers	Fish seed production	DOA	1,496,000
Projects at FDC, Bhairawa	as above	Fishfarmers	Fish seed production and Technology verification	DOA	2,414,000
Projects at FDC, Bhandara	as above	Fishfarmers	Technology verification	DOA	1,583,000
Projectrs at FDC, Kulekhani	as above	Fishfarmers	Reservoir fisheries development	DOA	1,032,000
Projects at FDC, Hetauda	as above	Fishfarmers	Fish seed production and Technology verification	DOA	3,135,000
Projects at FDC, Janakpur	as above	Fishfarmers	Fish seed production and Technology verification	DOA	2,586,000
Projects at Fisheries Training Centre (FTC), Janakpur	as above	Fishfarmers	Development of technical manpower	DOA	2,025,000
Projects at Kathmandu Central Fish Hatchery Balaju	as above	Fishfarmers	Fish seed production	DOA	950,000
Projects at FDC, Lahan	as above	Fishfarmers	Fish seed production	DOA	597,000
Projects at FDC, Fattepur	as above	Fishfarmers	Fish seed production	DOA	1,418,000
Projects at Aquaculture Extension Services	as above	Fishfarmers	Provision of extension services	DOA	

Note: (a) Project titles were not given; instead, the name of the centres where the activities re part of the regular programmes were mentioned. (b) All projects are implemented by the Department of Agriculture.

V. List of On-going Projects of Aquaculture Development Research Organizations

Title of Projects	Duration From/To	Target beneficiaries	Expected output	Implementing organiz.	Budget (in Nepal rupees)
Projects relating to pond fish culture: • Polyculture of carp with feed and fertilizer • Intensive nursing of fish fry • Control of disease • Multiple breeding of carp	1991-	Fishfarmers	Increased production	NARC (Fisheries Development Centres and Tribhuvan University)	3.5 million

Title of Projects	Duration From/To	Target beneficiaries	Expected output	Implementing organiz.	Budget (in Nepal rupees)
Projects relating to the development of production technologies: • Culture technology of trout in raceways • Breeding techniques of indigenous fish	1991-	Fishfarmers Entrepre-neurs	Increased production	same as above	3.0 million
• Genetic study of Indian major carps in wild and hatchery conditions	1994-	Fishfarmers	Increased production	same as above	5.0 million
Projects relating to cage fish culture: • Culture technique of planktivorous carps in cages • Culture of common carp with feed in cages	1991-		Increased production	same as above	4.0 million

VI. List of the Research Organizations Responding to this Survey

Fisheries Research Division of the Nepal Agriculture Research Council

Pakistan

I. Background

Aquaculture is relatively new to Pakistan and has not made a significant contribution to the national economy. A special development project "Pakistan Aquaculture Development Project" was implemented in February 1982 to upgrade aquaculture facilities, develop human resources and promote intensification of aquaculture, emphasizing effective utilization of inland open waters. About 20% of the total production from inland waters is attributed to aquaculture; this is mainly used to meet domestic requirements for animal protein.

Fish culture in Pakistan is traditionally practiced in earthen ponds of varying sizes, employing an extensive level of farming & polyculture system involving three indigenous carp species namely, *Labeo rohita, Catla catla* and *Cirrhina mrigala* with exotic species including *Cyprinus carpio, Hypothalmichtys molitrix* and *Ctenopharyngodon idellus* has been successfully developed over the years under local conditions. Some farmers are also culturing species like *Labeo calbasu, Labeo dero* and *Tilapia sp.* In addition, rainbow trout and brown trout are cultured in cold water/northern regions of the country. The development of shrimp culture in the province of Sindh met with some failures largely due to some technical problems which were beyond control in the past.

According to 1995 statistics, the total aquaculture production was 24,000 tons from 14,800 ha of production areas. Estimated number of people directly involved in aquaculture activity is 25,000.

II. National Aquaculture Development Plan

Directorate of Fisheries, Ministry of Food, Agriculture and Livestock (MOFAL) is responsible for formulation and implementation of the national aquaculture development plan.

II. 2 Objectives and Priorities of the National Aquaculture Development Plan

Aquaculture Development Objectives	Aquaculture Development Priorities
• To increase fish production to meet demand for animal protein • To generate the income and employment opportunities for small scale fishermen and fish farmers • To enhance foreign exchange earnings through exports • To manage and utilize fisheries resources in an environmentally sound and socially equitable manner	• Development of institutional infrastructure, i.e., hatcheries and nurseries • Mobilization of the private sector through demonstration and provision of incentives and extension services to aquafarmers • Development and management of open inland waters through efficient and optimum utilization of these resources • To maximize the production per unit area from the existing aquafarms and establish new farms for carp and trout • Improvement of the harvesting systems and marketing channels to enhance the farm income

II. 2 Processes and Criteria Used in Formulating the National Aquaculture Development Plan

Processes	Criteria Used	Participating Organizations
• Identification of needs by MOFAL and FAO missions • Review by the Agricultural Inquiry Committee • Directorate of Fisheries (DOF) prepares the plan on the basis of the sector studies that were coordinated by ADB and MOFAL • PC-I projects were formulated by all provincial department of fisheries.	• Production/availability of fish and fish seeds • Interest of public and private sectors • Potentials of aquaculture resource bases • Domestic and local demands for fish	• Government agencies, both national and provincial levels, Agricultural Inquiry Committee • Scientific community • Private investors, Donors and external agencies, e.g., FAO, ADB

Directorate of Fisheries, MOFAL prepares the national aquaculture development plan and the Provincial Department of Fisheries prepares the action plans on the basis of the national plan.

II. 4 Implementation of the National Aquaculture Development Plans

Strategies to be used in implementing the national aquaculture development plans are:

- Creation of basic infrastructure such as hatcheries and nurseries
- Promotion of commercial aquaculture in the private sector
- Training and development of human resources in aquaculture and related areas
- Provision of extension services and technical assistance to the fish farmers
- Assessment and management of aquaculture resource bases and stock replenishment
- Modernization of technology and improvement of marketing system

Action plans and objectives of the national aquaculture development plan

Action plan	Objectives	Target beneficiaries	Expected results
First Pakistan Aquaculture Development Project (1981-1986)	• To improve hatchery facilities • To establish new hatcheries • Training & human resource development • To promote private sector investment	• Private sector • Provincial fisheries departments	• Meet demand for seed • Private sector involvement in aquaculture
Second Aquaculture Development Project (1989-1996)	• To strengthen support services • To strengthen data collection • To promote carp and trout culture in provinces	• Private sector • Consumers	• Improved seed production facilities • Establishment of training centers • Mobilization of private sector

Changes and emerging issues resulting from implementation of the aquaculture development plans

Action plans	Changes and effects	Emerging issues	Actions required
First Pakistan Aquaculture Development Project (1981-1986)	• Functioning carp and trout hatcheries • Meeting the demand for seeds • Interest of private sector in aquaculture	• Need for improved extension services • Improved technical assistance and backup to farmers	• The Second aquaculture development project was formulated and implemented
Second Aquaculture Development Project (1989-1996)	• Improved and/or new hatcheries • Establishment of training centers • Mobilization of private sector	• Need for more demonstration farms • Need to attract private sector investment • Need to promote semi-intensive and intensive farming systems • Local hatcheries at reservoirs and dams • Integrated approaches among research, training and extension services	• Coordinated projects with financial assistance from international organizations to fill gaps in the sector.

II. 5 Issues and Needs in Formulating and Implementing the National Aquaculture Development Plan

Category	Issues	Constraints	Required Actions
Administrative & Institutional Aspects	• Weak institutional linkages and coordination among related agencies • Inadequate institutional infrastructure	• Lack of integrated approach • Inadequate coordination efforts	• Strengthen institutional linkages and coordination, from planning, research, to adoption and utilization of technologies
Legal Aspects	• N/A	• N/A	• N/A
Information	• Inadequate technology transfer • Lack of verified technologies and technology packages	• Shortage of extension specialists • Reluctance of farmers to accept new technologies • Lack of awareness	• Development of dedicated and trained extension specialists • Promote adoption and utilization of information
Human Resources	• Training, particularly extension specialists	• Shortage of dedicated & skilled personnel	• Training of existing staff • Recruitment of qualified staff
Technical aspects	• Appropriate & applicable technologies and management methods	• Lack of feed manufactures • Lack of technologies for pollution control and effluent treatment; high density stocking systems	• Development of commercial feeds • Improvement of management measures
Physical & Environmental aspects	• N/A	• N/A	• N/A

Category	Issues	Constraints	Required Actions
Socio-economic aspects	• Low price of fish • Poor marketing and transportation facilities • Eating habits of people • Lack of incentives for private sector	• Involvement of middlemen, i.e., indirect marketing • Lack of transportation and storage facilities • Consumer preference for big fish & underutilization of small size fishes	• Improved marketing system • Improved storage facilities • Awareness campaign through mass media

III. National Aquaculture Development Research

III. 1 Role, Objectives and Priorities of the National Aquaculture Research

The role of aquaculture research sector is:

- To develop improved technologies for the fish farmers
- To improve farm income through the use of economic inputs
- To develop appropriate plans for proper management and utilization of natural water bodies in order to boost fish production
- To conserve aquaculture resources from pollution and other hazards

The objectives of the research sector are:

- To increase fish production per unit area through improved and field-tested technologies generated from research
- To develop cost-effective and readily acceptable and applicable technologies for private sector
- To optimize utilization, sound management and conservation of aquaculture resources

Aquaculture research priorities and action plans/programmes

Research Priorities	Action Plans/Programmes	Expected Outputs	Implementing Organiz.	Target Beneficiaries	Duration From/To
Reservoir fisheries	• Stock assessment survey in and around Islamabad • Development of fisheries in Islamabad	• Improved management plans • Increased fish production	NARC DOF (Punjab)	Farmers Consumers	1990-96 1996-97
Genetic improvement of carps	• Genetic improvement of major carps • Genetic improvement of carps in Punjab	• Hybrids with improved performance • Genetically improved stocks for farming	NARC DOF (Punjab)	Farmers	1991-96 1996-98
Freshwater prawn farming	• Freshwater prawn farming at farmers' level • Freshwater prawn farming	• Commercial farms & farming	NARC MOFAL & DOF (Sindh)	Farmers	
Breeding of *Tor* (sp.)	• Breeding of mahaseer in NWFP • Development and improvement of mahaseer culture in high regions of Punjab	• Stock replenishment and mahaseer culture	DOF (NWFP) DOF (Punjab)	Farmers	1996-98

Research Priorities	Action Plans/Programmes	Expected Outputs	Implementing Organiz.	Target Beneficiaries	Duration From/To
Cage culture	• Introduction of cage culture in Punjab • Cage culture studies in NWFP	• Fish production through cage culture	DOF (Punjab) DOF (NWFP)	Consumers Farmers	1996-98
Farming systems	• Intensive culture of carp in ponds • Intensive trout culture in NWFP	• Improvement of yields	DOF (Punjab) DOF (NWFP)	Farmers Consumers	1996-97

III. 2 Processes and Criteria Used in Formulating Aquaculture Development Research Plan and Priorities

Types of Organization	Process	Criteria	Participants
National Aquaculture Research Planning Agency	• Research priorities are highlighted at a variety of fora • Consultation with related agencies and organizations at all levels	• Increased production rate • Farmers & local needs • Innovation, e.g., better management practices • Contribution to national economy • National development needs	• Central research organizations, e.g., NARC, PARC • Research units of provincial DOFs • Relevant groups from academic institutions
Aquaculture Research Organizations	• Consultation with central & provincial government agencies • Consultation with fish farming communities • Consultation with private sector	• Conservation & protection of natural stocks under the threat of collapse • Needs of private sector • Needs of fish farming communities • National development needs • Interests of donors & their • funding criteria	• National government agencies such as NARC, PARC and other related bodies • Provincial fisheries agencies • Researchers and staff of the research organizations

NOTE: The Livestock Division of Ministry of Food, Agriculture and Livestock, in collaboration with NARC, is responsible for formulation and coordination of the national aquaculture research policies and plans The central research organizations such as NARC and PARC play a key role in setting the research priorities and by conducting in-house aquaculture research.

III. 3 National Aquaculture Development Research Capacity

List of key aquaculture development research organizations

Key Aquaculture Research organizations	Institutional affiliation	Areas of Competence
Pakistan Agriculture Research Council (PARC)	Agriculture Research Division, MOFAL	Coordinated research on applied areas of aquaculture
National Agriculture Research Center (NARC)	Agriculture Research Division . MOFAL	Problem-oriented applied research
Marine Fisheries Department	Livestock Division , MOFAL	Limnology & postharvest methods, harvesting technologies
Research and Training Center (Punjab)	Directorate of Fisheries of Punjab	Problem-oriented applied research

Key Aquaculture Research organizations	Institutional affiliation	Areas of Competence
Center of Excellence in Marine Biology Karachi University	Min. of Education	Taxonomic & basic research
Department of Zoology, Univ. of Punjab, Lahore	Min. of Education	Biological & toxicological aspects of fish culture
Department of Biological Sciences, Quaid-e-Azam Univ., Islamabad	Min. of Education	Biological & reproductive areas
Department of Zoology, Faisalabad Univ.	Min. of Education	Biological & management aspects
Department of Zoology, Multan University	Min. of Education	Biological & management aspects
Pakistan Science Foundation, Islamabad	Ministry of Science and Technology	Basic & taxonomic research

Adequacy of research capacity in meeting the national aquaculture development needs

Aquaculture Development Priorities	Priority Research Needs	Adequacy*
Breeding of *Tor* (sp.)	• Breeding in semi-cold waters • Culture of mahaseer under capture conditions	2 2
Freshwater prawn farming	• Establishment of hatchery • Culture techniques	3 3
Genetic improvement of major carps	• Hybridization of carps • Polyploidization/ gynogensis techniques	3 2
Promotion of semi-intensive or intensive aquaculture	• Commercial feeds for carp culture • Farm management techniques to enhance yield	2 2
Integrated fish farming approach	• Integrated fish farming with ducks or poultry • Integrated model farms at commercial scale	2 2
Intensive farming of trout	• Establishment of demonstration farms	3
Mariculture (pearl, oyster, seaweed culture)	• Finfish breeding and culture of milkfish, grouper and seabass • Pearl culture • Seaweed culture	1 2 2
Reservoir fisheries	• Stock assessment of reservoirs, dams and natural water bodies • Regular stock replenishment to optimize production • Weed control in reservoirs and improved harvesting systems	3 2 1
Rice-fish culture	• Tilapia/carp culture in rice fields • Air-breathing fish culture in rice fields	2 1
Utilization of saline and water-logged areas for fish culture	• Species that are known to be suitable for culture in saline waters, e.g., tilapia • Identification of new suitable species for culture in saline areas	2 1

* 1 - no capacity; 2 - inadequate; 3 - adequate; 4 - good; 5 - excellent

III. 4 Programs of the Key Aquaculture Research Institutions

List of the programmes of the key aquaculture development research organizations

Priority areas	Objectives	Place
Fish breeding and genetics	• To study factors for controlling and affecting fish reproduction	DOF (PUNJAB)
	• Development of breeding technology for major carp • Hybrid development and performance testing: Labeo & Catla	NARC
	• To study effect of different feed ingredients on growth of genetically improved stocks • To study effects of inducing agents used in artificial spawning of Carps and Mahaseer • To improvement in artificial spawning techniques	DOF (PUNJAB & NWFP)
	• To establish a hatchery complex for commercially important species, i.e., shrimp	DOF (SINDH)
Fish nutrition and growth physiology	• To develop cost effective feed formula for trout • To study effects of various formulated feed on survival and growth of trout fry and fingerlings	DOF (NWFP)
	• To formulate adequate and cheap feeds for local species and to develop techniques for promoting rapid growth	DOF (PUNJAB)
Fish culture system	• Rational development of freshwater aquaculture by using agroclimatic parameters	DOF (PUNJAB)
Freshwater prawn culture	• To develop culture technologies for Macrobrachium spp.	DOF (SINDH) (in development)
Reservoir fisheries	• To study population dynamics, species composition • To establish parasitic profile and dynamics in selected species	NARC DOF (PUNJAB)
Fish toxicology	• To determine toxic environmental levels of xenobiotic chemicals, heavy metals and pesticides	Punjab University

Number of research personnel by areas of specialization

Specialization	Ph D	M Sc	B Sc	Res. Assist.	Total
Biological sciences	10	23	17	31	*81*
Economics	1	1			*2*
Legislation	1	2			*3*
Physical and Engineering sciences	2	2			*4*
Social sciences	2	2			*4*
Total	*16*	*30*	*17*	*31*	**94**

Note: The scientists & specialists in the main agricultural research organizations such as PARC and NARC often participate in aquaculture research programs.

III. 5 Dissemination and Utilization of Research Outputs

Target Groups	Methods used to transfer the research outputs
Policy planners & Political levels	• Reports; Published materials
Managers of government agencies	• Reports ; Meetings and seminars
Fish farmers & fish farming community	• Extension - Demonstration & training; Seminars & workshops; Technical advice; Participatory research & problem solving; Newspapers; Media, brochures

Target Groups	Methods used to transfer the research outputs
Private sector & Supporting industries	• Participatory research & problem solving; Broadcast and print media
Research community	• Publications (Progressive Fish Farmers); Seminars; conferences
Extension community	• Technical assistance
General public	• Mass media, e.g., radio, TV, newspapers, Open-house

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research Programs

CATEGORY	ISSUES	CONSTRAINTS	REQUIRED ACTIONS
Administrative and institutional Aspects	• Low priority to aquaculture • Coordination among research agencies • Uncoordinated research planning and policies	• Lack of qualified personnel • Lack of direction, coordination and leadership	• Leadership by the central agencies • Improved coordination of research plans and policies, e.g., designate research planning and coordination to one central agency such as Central Inland Fisheries Research Institute • Networking and collaboration among research organizations and programmes, both at national and international levels • Increase public awareness and support for aquaculture
Human Resources	• Shortage of skilled research personnel • Inability to recruit project staff	• Lack of concerted efforts • Lack of skilled personnel • Lack of funds and facilities • Lack of appropriate courses at graduate & postgraduate levels	• Recruitment of staff with appropriate qualifications • More graduate courses in fisheries offered by major universities • Strengthening of the NARC fisheries institutions • Attract more financial resources • Organization of exchange programs for scientists
Information	• Lack of mechanisms for dissemination of research results • Poor information utilization • Inadequate extension services • Ineffective information dissemination • Timeliness and cost of information	• Lack of coordination between research and extension • Lack of tested and validated technologies • Lack of concerted efforts in technology transfer • Lack of extension officers and funding	• Coordinated actions/programs between extension and research agencies/programs • Development of extension specialists • More field or adaptive research • Coherent approaches • Timely dissemination of information at national rates
Research Environment	• Inadequate research facilities • Inadequate dialogues and interaction between concerned parties • Funds for aquaculture research • Lack of field oriented research	• Unavailability of funds • Infrequent or no interaction between researchers and users of research outputs • Low priority given to aquaculture • Lack of interactions between researchers and users	• Need to include appropriate and adequate budget items in all research projects • Regular consultations at all levels and stages of research • Promote participation of and consultation with users of research outputs • Increased grants to Universities • Influence policy making and allocate more funds to aquaculture research • Support for and encouragement of applied research

Other suggestions:

- International and regional collaboration and external financial supports are needed.

IV. List of On-going Projects of Aquaculture Development Agency

Projects	Duration From/To	Target beneficiaries	Expected outputs	Executing agency	Budget (Rupees)
Development of hatchery complex for marine shrimp & finfish	1995-97	Fishfarmers, Consumers	To produce shrimp & marine fish seed for coastal aquaculture	MFD, DOFAL	19.0 m
Second Pakistan Aquaculture Development Project	1989-96	Fishfarmers	To strengthen support services & production programmes for carp & trout culture	Provincial directorates of fisheries	US$ 4.5 m ADB - US$ 15.0 m
Determination of soil and water criteria to optimize production	1995-96	Fishfarmers	Technical assistance to fishfarmers	DOF (Punjab)	0.12 m
Strengthening of fisheries extension services	1995-97	Fishfarmers	Provision of training & extension facilities	DOF (Punjab)	7.32 m
Improvement of nursery units in 4 districts	1995-97	Fishfarmers Public sector	Provision of fish seeds Open water stocking	DOF (Punjab)	2.5 m
Promotion of fish culture in Layyah	1995-97	Private sector	Promotion of pond culture	DOF (Punjab)	2.9 m
Pilot project for murrel (*Channa* sp.) culture	1995-97	Private sector	Introduction of murrel culture	DOF (Punjab)	1.14 m
Control of fish fry production by local chemicals	1995-97	Private sector	Farm management techniques	DOF (Punjab)	1.22 m
Establishment of pituitary extraction unit in Haripur	1993-96	Fishfarmers	Use of PG material for breeding	DOF (NWFP)	1.8 m
Development of trout fish in Mansehra district (phase 1)	1993-96	Fishfarmers	Promotion of trout culture	DOF (NWFP)	0.258 m
Establishment of nurseries in D. I. Khan	1993-96	Fishfarmers	Provision of fingerlings to farmers and restocking natural waters	DOF (NWFP)	1.0 m
Rehabilitation of mahseer fish in Dir Malakand	1993-96	Consumers	Improvement of natural stocks	DOF (NWFP)	1.5 m
Feasibility study for establishing freshwater prawn hatchery	1996	Fishfarmers	Assessment of feasibility for freshwater prawn culture at commercial level	Min. Food Agri. & Livestock	US$ 42,000

V. List of On-going Projects of Aquaculture Research Organizations

Projects	Duration From/To	Target beneficiaries	Expected outputs	Participating organizations	Budget
Growth and reproduction of major carps	1980-	Extension agencies	Standard culture techniques	Dept. of Zool,, Punjab Univ.	Rs 50,000
Sex differences in growth of tilapia	1990-	Extension agencies	Optimum conditions for culture	Dept. of Zool., Punjab Univ.	Rs 50,000
Biological toxicology	1980-	Extension agencies	Water quality criteria for cultured species	Dept. of Zool,, Punjab Univ.	Rs 150,000
Reservoir fisheries management	1989	Farmers and national agencies	Management regimes	AFRI, NARC Farmers	Rs. 0.7 Million
Carp breeding and genetic improvement	1988-	Farmers	Breeding of carps and hybrid evaluation	AFRI, NARC	Rs. 0.3 Million
Freshwater prawn culture	1990-95	Farmers	Culture techniques	AFRI, NARC, Farmers	Rs. 0.2 Million
Effects of parasitism in reservoir fishes	1994-96	Farmers	Determination of economic importance of various parasites	AFRI, NARC	ODA £10,000
Hatchery complex	1995-98	Fish & shrimp farmers	Availability of seeds Employment opportunities	Marine Fisheries Dept. MOFAL	Rs 18.9 million

VI. List of the Main Aquaculture Research Organizations Responded to the Survey

1. Aquaculture and Fisheries Research Institute (AFRI), Pakistan Agricultural Research Council (PARC), Ministry of Food, Agriculture and Livestock, Government of Pakistan
2. Marine Fisheries Department, Ministry of Food, Agriculture and Livestock, GOPakistan
3. Directorate of Fisheries, NEFP, Peshawar
4. Department of Zoology, Punjab University, Lahore

Philippines

I. Background

Aquaculture industry in the Philippines has a long history. It started with milkfish culture in brackishwater ponds in the 14th century. However, its importance was only recognized in 1940, when developed brackishwater areas significantly increased to 60,000 hectares and produced about 20,000 mt. To date, aquaculture area has dramatically increased to 239,323 hectares of brackishwater ponds and 14,531 hectares of freshwater ponds, cages and pens widely distributed in different parts of the country. Out of the total developed fishponds, only 59.8% of the brackishwater and 44.9% of freshwater ponds are effectively utilized for fish production. The rest are idle or unproductive.

Aquaculture is a countrywide activity. It is sub-divided into three sub-sectors: brackishwater, freshwater, and marine culture. Aquaculture practices vary from province to province and/or region in accordance with production level, culture system, management practices, and the species cultivated. The magnitude of difference in operation and management is greatly influenced by the available resources, markets consumers demand, and the individual farmer's financial capability. Freshwater aquaculture started to develop at a more rapid pace in the 1970's.

In 1995, the aquaculture sector produced around 825,400 mt of fish valued at Pesos 33.3 million (1 US$ = 26 Pesos), from a production area of 162, 234 hectares. It is only from this sector that a steady production was attained compared with commercial and municipal fisheries sector since 1990. The sector generated employment for some 258,480 people. With the benefits derived from aquaculture, its sustainable development is of common concern among agencies and bodies involved in the industry. The sector is envisioned to be the vital source of fish protein in the future as well as a major source of income, employment and foreign exchange.

II. National Aquaculture Development Plan

The Bureau of Fisheries and Aquatic Resources (BFAR) under the Department of Agriculture (DA) is the lead agency mandated to formulate, implement, monitor and evaluate national fisheries and aquaculture development and management, including conservation plans, programs and projects.

II. 1 Objectives and Priorities of the National Aquaculture Development Plan

The contributions of aquaculture to national development are:

- To fill the gap in fish supply cause by the declining or leveling off of fish catch from capture municipal and commercial fisheries.
- To produce aquaculture commodities with export potential to increase foreign exchange earnings.
- To produce fish species for domestic consumption, it being a cheap source of animal protein.

All activities are focused towards maximizing aquaculture production. However, all R and D activities are planned in consonance with environmental protection, conservation and sustainable resource use.

Aquaculture Development Objectives	Aquaculture Development Priorities
• To enhance the overall productivity of fishery resources, within ecological limits. • To alleviate poverty, particularly of small-scale fishfarmers • To double aquaculture productivity, from 1.2 to 2.4 metric tons per ha per yr.	• To increase production of the priority species, i.e., milkfish, shrimp, tilapia, carp, seaweed and crab • To secure adequate supply of quality seeds for the priority species • To apply effective technologies and cost-effective feeds that will not contribute to environmental degradation • To manage fisheries in inland waters within the concept of sustainable yield with the integration of fisheries management, conservation and protection

II. 2 Process followed in formulating the aquaculture development plans and priorities

Processes	Criteria	Participants
I. National consultations and sectoral workshops II. Regional, local and sectoral workshops or consultations	I. National development needs II. Priorities identified by farmers, private sector, local governments	I. Government II. Fisheries organizations & private sector III. Local governments IV. State colleges and universities V. Regional representatives from the same sectors above

II. 3 Implementation of the National Aquaculture Development Plans

The National Aquaculture Development Plans of the Philippines known as the Gintong-Ani (Golden Harvest) for Fisheries, was simplified and packaged to respond to the revitalized food security agenda approved and adapted during the Food Security Summit. It provides the blueprint for coordinating, monitoring, regulating and managing the sustainable growth and development of aquaculture and inland fisheries, under a single institutional framework. The present multi-agency nature of managing aquaculture and inland fisheries is complex, which sometimes results in conflicting use of common resources. Problems and issues on aquaculture will be addressed through integrated and coordinated approach by:

- multi-agency participation and interaction;
- participatory planning and management by stakeholders and other aquatic resource users;
- resolution of conflict between stakeholders and other resource users; and
- prevention of environmental degradation for sustainable aquaculture and inland fisheries.

Strategies to be followed in implementing the national aquaculture development plan are divided by commodity priority, as follows:

Commodities	Development strategies
Milkfish and shrimps	• Implementation of the National Milkfish Broodstock Development Program • Promotion of environment friendly aquaculture technologies (semi-intensive, polyculture & modular systems) through intensified extension service • Continued research on waste management/treatment in shrimps • Study on the use of indigenous biodegradable substances for snails control in milkfish ponds.

Commodities	Development strategies
Tilapia and carp	• Continuation of the GIFT-PNTBP (Philippine National Tilapia Breeding Program) • Promotion of polyculture system of carp and tilapia in upland and landlocked areas • Mass production of quality fingerlings • Research on fish health management • Establishment of fish health laboratory in strategic regions
Inland water resources management	• Inland water profiling, stock assessment and precaution of management plan for the seven (7) major lakes • Review of previous stocking activities by BFAR prior to implementation of the plan based on fish existing food and ecological niche • Strengthen linkages with organizations and institutions involved in fisheries.
Seaweed	• Genetic improvement of *Eucheuma* species on establishment of gene-bank • Development of farming technology for *Gracilaria* spp. • Extension and technical services
Crabs	• Assessment and management of resources • Seed production and hatchery technology • Promotion of crab culture and fattening technology

Action plans and objectives of the national aquaculture development plan

Action plans	Objectives	Target beneficiaries	Expected results
Key fisheries development areas in aquaculture	• To achieve sustainable aquaculture production • To alleviate poverty	• Private sector • Fishfarmers	• Increased production from aquaculture
Key fisheries development areas in lake management	• To manage and conserve the lake ecosystem • To make a biological assessment of, and formulate and implement , a lake management plan	• Local government units • Government • Non-government organizations • Stakeholders	• Formulated lake management plan • Sustainable resource use and production

Changes and emerging issues resulting from implementation of the aquaculture development plan

Action plans/Change or effect	Issues	Actions required
Key fisheries development areas in aquaculture		
• Intensified transfer of hatchery technology to the private sector	Difficulties in distribution of milkfish breeders to certain regions	• Division of responsibilities among participating institutions • Coordination with financing institutions (re credit for fishfarmers)
• Three regions completed mapping of aquaculture production areas		
• Accreditation of private hatchery owners to maintain supply of good quality tilapia seed		
• Increased aquaculture production on a roll-over financing scheme	Non-profit credit assistance	
• Identified sites for seaweed seed bank • Stock assessment of seaweed resources		Establishment of seed bank
• Utilization if mollusc and seaweeds as biofilter for brackishwater fishfarms		
• Fish health management		Establish regional field laboratories for fish health management
• Tilapia-carp polyculture in fertilized pond		
• Stock improvement of Chinese major carps		
• Testing of newly developed carp performance		Develop more comprehensive project funded under the RP-Chinese protocol
• Use of cowpea as fish meal substitute and as binder; Low cost feed		Technology packaging and commercialization

Action plans/Change or effect	Issues	Actions required
Key Fisheries Development Areas for Lake Management		
• Formulation of lake management plan and biological assessment of major lakes	Resource use conflicts	• Lake profiling • Standardized stock assessment method and management
• Training on sustainable management of freshwater ecosystem		
• Stock assessment of the major fishery resources of Laguna Lake and their level of exploitation		

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspects	• Low aquaculture production		• Strengthen and encourage cooperative development actions • Improved mechanisms for coordination, monitoring and evaluation of action plans • Strengthen capacity of the coordinating agency
Legal aspects	• Lack of legal framework for aquaculture	• Inhibiting land tenure • Lack of appropriate aquaculture policies	• Exemption of aquaculture areas from Comprehensive Agrarian Reform Law (CARL) • Review of policy regulations
Information	• Centralized data gathering and information dissemination	• Weak information exchange and networking in the marketing aquaculture products • Slow adoption of improved technology	• Assistance in market matching of products and market development • Provision of infrastructure and marketing facilities • Information campaign on environmental protection & improved technologies • Operationalize the Philippine Fisheries Information System
Human resources	• Weak linkages with related agencies and organizations • Lack of skilled personnel in extension and technical services	• Devolution of extension functions to local government units	• Programmes to upgrade skills of technical and extension officers Organize training seminars and workshops
Technical aspects	• Insufficient supply of fry and fingerlings • High cost and poor quality of feeds • Lack of biodegradable pesticides to control snails in ponds • Disease outbreak • Lack of effective quarantine measures for newly introduced species • Lack of technologies for water recycling for semi- & intensive farms	• Poor quality of seeds	• Continuation of GIFT-PNTBP • Promotion of polyculture system of carp and tilapia • Research on biodegradable pesticides and waste management and treatment • Promotion of environmentally friendly culture technologies • Undertake productivity enhancement programs • Introduce effective quarantine measures
Physical and environment aspects	• Environmental conservation and production • Integration of inland water area management	• Waste dumping • Pollution and environmental degradation	• Enforcement and monitoring of laws on waste disposal • Inland water area profiling and development of integrated management plan

Category	Issues	Constraints	Required actions
Socio-economic aspects	• Credit assistance • Poverty alleviation of small-scale fishfarmers	• Deficiencies in the delivery of credit • Lack of operating capital for aquaculture operators	• Implement prototype fisheries financing projects • Expand support for insurance, guarantee and other risk reducing mechanisms to encourage private sector join fisheries financing • Recommit seed funds to priority areas/projects

III. National Aquaculture Development Research

III. 1 Objectives and Priorities of the National Aquaculture Development Research

The main body responsible for the national aquaculture research plan in the Philippines is the Philippine Council for Aquatic and Marine Sciences Research and Development (PCAMRD). The main functions of the national aquaculture research sector are (a) to provide a scientific basis for decision-making on the implementation of an integrated program for research and management of our inland water bodies and (b) to support the national economy through the development of new technologies for sustainable utilization of ponds, lakes, reservoirs, rivers as well as other inland water resources.

The national aquaculture development research plan is outlined in the National Fisheries and Aquatic Resources Research Agenda (NAFARRA). It is a 5-year Research and Development Plan aimed to synchronize all research efforts. It regulates resource allocation to improve the fishery resource productivity by strengthening cooperation among research implementors, with emphasis on environmental concerns. The NAFARRA is consistent with the government policy on the revitalized food security agenda, rationalized management of the fishery resources for sustainable use, environmental rehabilitation, poverty alleviation and improved productivity, with the necessary policies and institutional reforms for the government and non-government institutions.

The long-term objective of the research plan is to assist the aquaculture sector to attain sustainable development through the:

- Provision of necessary data, information and experience to improve the productivity and overall production of existing aquaculture systems;
- Development/Improvement of technologies which are both economically viable and ecologically attuned with the supporting environment; and
- Assessment of inland waters for integrated management.

Research priorities are given to the export winners and domestic commodities of the country.

Aquaculture development research priorities

Export winners			
Research Areas	**Research Programs**	**Expected outputs**	**Implementing Organizations**
Shrimp	Development of low cost feed and testing of fishmeal substitutes	• Formulation of low-cost shrimp diets	SEAFDEC; UPV; BFAR; DENR; SUCs; NGOs Private sector
	Disease control and prevention	• Shrimp disease diagnostic kit and recommendations for disease prevention	same as above
	Broodstock development	• Good quality broodstock and increased production of fry	same as above
	Environmental degradation	• Policy recommendations on proper management of the environment • Policy recommendations on the proper management of organic loading • Guidelines on the control of groundwater extraction • Policy recommendations on the use of pesticides and toxic chemicals for aquaculture • Package of technology on waste water treatment for aquaculture	DENR; UPV BFAR; SEAFDEC SUCs; BSWM CLSU
Crabs	Development of hatchery larval rearing & grow-out culture technology	• Increased availability of seedstocks • Increased production of mudcrab	DENR; MSU BFAR; SEAFDEC; DA UPV; PNAC
	Feed development	• Reduced production cost and increased profit	same as above
Seaweeds	Genetic improvement Development/production of cultivars	• Development of fast growers, disease-resistant and HYV/cultivars	UP-MSI; ITDI SUCs; SIAP DA; SEAFDEC Private sector
	Development of technologies for hatchery and grow-out production for seaweeds	• Technology for hatchery production of seaweed germlings	same as above
	Inventory, assessment and management of natural stocks (*Gracilaria* and *Sargassum*)	• Management strategies for the natural stocks of Graclaria and Sargassum	same as above
Basic domestic needs			
Milkfish	Broodstock development and seed production	•	
	Refinement of breed in hatchery techniques	• Increased fry production	SEAFDEC
	Assessment of hatchery technology adoption and extension (seed production)	• Technology and information on milkfish hatchery operation	SEAFDEC DA; BFAR UPV
	Polyculture system with other species	• Polyculture technology of milkfish and other fish species	Private sector
	Crop rotation /integrated farming system	• Improved production management strategies • Increased fishpond production	
	Development of locally available and low cost diets	• Formulation of low-cost and practical milkfish feeds	

Research Areas	Research Programs	Expected outputs	Implementing Organizations
Tilapia	Development of tilapia breeding and genetic improvement program	• Improved breeds and strains of tilapia for culture	DA; BFAR; NFFTRC CLSU-FAC; SEAFDEC; LLDA; PCAMARD; DENR; SUCs Private sector
	Pond and cage culture of tilapia in brackishwater	• Technology on brackishwater pond and cage culture of tilapia and other fish species	same
	Productivity enhancement	• Increased productivity • Sustainable utilization of developed fishfarms	
	Formulation of low-cost feeds from locally available feed ingredients	• Low-cost tilapia feeds	BFAR CLSU SEAFDEC
	Policy studies on the utilization of lakes, rivers and reservoirs for aquaculture	• Policies and regulations on use of lakes, rivers and reservoirs for aquaculture	SUCs; BFAR PIDS Local gov.

Other priority areas

Research Areas	Research Programs	Expected outputs	Implementing Organizations
Catfish, carp, grouper, macrobrachium, seabass, siganid, sea urchin, tridacna, pholas, placuna, abalone	Breeding Seed production	• Increased/sustained production of good quality broodstock and fry • Technology for breeding and seed production	SEAFDEC UPV; BFAR DA; SUCs Private sector
Seabass, grouper, siganid, pholas, placuna, sea urchin, abalone, tridacna	Improvement of grow-out culture systems & technologies	• Development of site-specific culture technologies • Increased production • Packages of grow-out technologies for commercially important species	
Grouper, seabass, siganid, catfish	Feed development	• Low-cost quality feed for aquaculture • Increased production of locally produced aquafeeds • Development of new sources of feed • Guidelines on feed production and feed quality control	SEAFDEC DOST; UPV DA
Institutional policy studies	Institutional policy studies	• Inventory of current aquaculture development practices • Evaluation of current aquaculture development & assessment of adoption rate of these practices • Recommendations on technology transfer • Inventory of fishery laws in aquaculture • Recommendations on improvement of aquaculture laws and enforcement	BAR; UPLB DA regional offices SUCs Local gov.

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plans and Priorities

Type of organizations	Processes	Criteria	Participants
National research coordinating agency (PCAMRD)	• Consultative or participatory approach among related agencies • Plans are set and • priorities made through a variety of consultation, including workshops	• STAND-2000 of DOST-PCAMRD • NFRD of Fisheries Sector Program • The Medium Term Fisheries Management and Development of DA-BFAR	• DOST-PCAMRD's leadership DA-BAR & BFAR, • SCUs and research institutions, • Private sector • NGOs & People's organizations • Local governments

Type of organizations	Processes	Criteria	Participants
Research organizations	• Individual initiative • Feedback mechanisms from all sectors involved in aquaculture • Inter-division/agency consultation	• National and development needs or priorities • Farmers' & local needs • Requests by clients; needs of clients • Criteria of funding agencies • Research competence • Scientific value • Availability of funds	• Researchers • Farmers/ clients • Representatives of funding agencies

Direction, coordination, monitoring and evaluation of researches are provided by PCAMRD.

III. 3 National Aquaculture Development Research Capacity

List of key aquaculture research organizations

Research organization	Affiliation	Area of competence
Bureau of Fisheries and Aquatic Resources, Quezon City	Department of Agriculture	All aspects of aquaculture
Bureau of Agricultural Research, Quezon City	Department of Agriculture	All aspects of aquaculture
UP Marine Science Institute, University of the Philippines Diliman	Autonomous	Coastal and marine aquaculture
Freshwater Fisheries Research Station, Bambang, Los Banos	Department of Agriculture	Freshwater aquaculture
Freshwater Aquaculture Center, Central Luzon State University, Munoz, Nueva Ecija	Department of Education	Freshwater aquaculture Tilapia (all aspects)
Brackishwater Aquaculture Center, University of the Philippines Visayas Leganes, Iloilo	Autonomous	Brackishwater aquaculture
SEAFDEC/AQD	Department of Agriculture	all aspects of aquaculture
Institute of Fisheries and Development, Mindanao State University, Naawan, Misamis, Oriental	Department of Education	Breeding & larval rearing; Nutrition; Disease control; Pond culture; Cage culture
Laguna Lake Development Authority, Department of Environment and Natural Resources, Pasig City	Department of Environment and Natural Resources	Water quality management; Lake fisheries; Lake limnology

Adequacy of research capacity in meeting national aquaculture development needs

The National Aquatic Resources Research and Development System (NARRDS) is a nationwide network of institutions involved in fisheries research and development activities. The members of the network conduct basic and applied researches on one or more commodities, package the technology, and transfer te information to the clients. Mature and verified technologies are also extended to the farmers. The network is composed of more than 40 members. Mostly, state universities and colleges (SCUs), Regional centers, cooperating stations and specialized collaborating agencies. The direction, coordination, monitoring and evaluation of researches are provided by PCAMRD. To some extent, advanced degree programs and non-formal training of the network staff are financed by NARDDS.

The research consortia are formed in areas where two or more adjacent or contiguous research agencies serve one region. This arrangement facilitates sharing of resources and capabilities or researches for more efficiency and economy. There are 13 existing regional consortia in the country which is in line with the objectives of decentralization of R & D management.

III. 4 Programs of the Key Aquaculture Research Institutions

List of the programs of the four aquaculture research organizations (see items IV and V for the list).

Res. Programmes	Priority Areas	Date Impl'td	Organizations
Fish Genetics	• Tilapia genetic selection • Validation of YY-male technology	1988	FAQ-CLSU
Fish nutrition	• Enzyme evaluation - tilapia	1996	FAQ-CLSU
Disease and Parasites	• Motile Aeromonad Septicemia • Streptococcus and Aeromonad septicemia • Vaccination of Nile tilapia		FAQ-CLSU
Culture systems	• Use of bagasse • Integration of azolla-duck & fish • Fertilization trials	1994 1995 1993	FAQ-CLSU
Seaweed	• Agar producing species	1987	MSI-UP
Invertebrates	• Giant clams • Sea urchins • Zooplankton • Lobsters	1986 1993 1990 1993	MSI-UP
Microalgae	• Planktonic & benthic diatoms • Toxic algal species • Zooxanthellae	1987 1993 1995	MSI-UP
Laguna de Bay	• Lake primary productivity study • Polyculture study • Culture of tropical aquarium fish • Freshwater pearl culture		LLDA
Breeding & larval rearing	• *Scylla serrata* • Gracilaria Sporelings • Imbaw, *Anodontia edentula* • *Siganus guttatus*		MSU-IFRD
Nutrition	• Proliferation of *Diaphanosoma* sp.		MSU-IFRD
Disease Control	• *Scylla serrata*		MSU-IFRD
Pond culture	• Pigok • Utilization of agarophytes and alginophytes		MSU-IFRD
Cage culture	• Abalone, *Haliotis* sp. • Mudcrab		MSU-IFRD
	• Status of corals		MSU-IFRD

Number of research personnel of four research organizations (see VI for the names of the organizations reporting)

Specialization	Ph D	M Sc	B Sc	Res. Assist.	Total
Biological sciences	14 (2)	14 (2)	37 (2)	7	72 (6)
Economics	1	2	1		4
Legislation	1				1
Physical and engineering sciences	1		1		2
Social sciences	1		3		4
Others	1	6	2		9
Total	19 (2)	22 (2)	44 (2)	7	92 (6)

Figures in parentheses ( ) indicate that the persons involved are on part-time basis.

III. 5 Dissemination and Utilization of Research Outputs

The research organizations participating to this survey indicated that their research outputs are disseminated through the following methods:

Target groups	Methods used to transfer research outputs
Policy planners, political level	Technology fairs; DOST technology training centers; proceedings of seminars and workshops; Informal and formal communications; Academic and semi-technical publications
Administrators and managers	Project review; Technical reports
Fishfarming community	Technology packaging; Hands-on training; Farm demonstration
Private sector and supporting industries	Investors' fora; Investment clinic; Technology fairs; Consultancy for agricultural productivity enhancement, brackishwater aquaculture Contracted research
Research community	Project review; Scientific publications; Seminars and talks
Extension community	Outreach publications; Manuals; Seminars/workshops
Public in general	Technology primer; Technology manual; Press releases; Manuals and brochures
Funding agencies	Technical reports

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Development Research

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Research orientation, e.g., Institutions become isolated centers of excellence & tend to focus on research activity, not on results • Lack of collaboration among related organizations and programs • Poor administration of funds • Low priority given to research	• Funding constraints • Lack of collaborative mechanisms • Delayed release of funds • Lack of efforts on the part of research institution • Lack of policy direction	• Strengthen national aquaculture research policies • Strengthen research coordination and mechanisms for collaborative research • Give basic research priority in technology development • Rational allocation of funds and national subsidy • Generate funds and support for research • Streamline financial procedures in fund releases
Legal aspects			
Information	• Lack of exchange and sharing • Ineffective technology transfer • Lack of mechanisms for disseminating research output • Poor utilization of research outputs	• Inadequate or no networking among related institutions • Inadequate mechanism for technology transfer • Inadequate packaging of research results and inappropriate communication mechanism • Inadequate library • Lack of institutional efforts to establish MIS • Lack of coordinated efforts in disseminating research outputs • Poor communications systems • Lack of funds	• Strengthen information networking • Develop mechanisms for technology transfer • Use broadcast media and popular publications for information dissemination • Develop information repackages in the context of user needs • Identify funding sources for information activities

Category	Issues	Constraints	Required Actions
Human resources and research competence	• Difficulty in attracting and motivating aquaculture researchers • Economic shortage of committed researchers • Lack of skilled personnel • Lack of manpower for research programs	• Requirements for specialization • Lack of funds for recruitment • Retrenchment • Researchers involved in too many activities	Staff development through training Provide advanced training Institutionalize [research] center
Research facilities	• Inadequate equipment and laboratory facilities • Lack of research facilities	• Low budgetary allocation	• Identify other funding sources and improve research facilities
Research environment	• Lack of research in critical areas (genetics, disease prevention, mass production of important species) • Lack of farmer participation in research priority setting • Lack of local community participation in research priority setting • Lack of funding	• Lack of facilities and trained manpower and expertise • No or little dialogue on actual farm situation or institution-farmer dialogue • Lack of collaboration with fishfarming community in general • Low priority given to aquaculture research	• Increased interaction between scientists and farmers • Motivate farmers to participate in research • Conduct trials (technology transfer) with farmers at the outset • Promote participatory research

Other suggestions:

- Give higher priority for inland water bodies in channeling funds for aquaculture research.
- Establish aquaculture research consortia to provide problem-oriented research and information sharing.

Aquaculture development and research needs that are not addressed by existing programs and projects:

- Assessment of reef enhancement research with cultured organisms
- Biodiversity studies of seaweed and other marine resources
- Research on indigenous species of fish
- Environmental issues/biodiversity studies
- Development of low-cost feeds
- Socio-economic issues and studies

IV. List of On-Going Projects of the Agency Responsible for Aquaculture Development

Project title	Date Impl'td	Expected outputs	Target beneficiaries	Implementing organizations
Fisheries Sector Program Research and Extension Component (Program IV is Aquaculture)	1990-95 (with extension of some activities to 96) Most of the research projects have been completed by 1996	Strengthening of the fisheries sector	fisheries industry sector	BFAR (ADB loan)
FGBP	3/15/95-97	Commercialization of YY technology for tilapia	farmers	BFAR,
GMIT-TAD	1994-96	YY male technology for large scale production of	farmers	UCS,Wales

Project title	Date Impl'td	Expected outputs	Target beneficiaries	Implementing organizations
		monosex male progeny for culture (tilapia)		
GIFT	1988-96	Productive stocks of tilapia	farmers	ICLARM, FAC, BFAR-NFFTRC
AZOLLA	1995-96	Azolla as fish feed component	farmers	UHawaii, GMIT, UCS, BFAR-NFFTRC
CRSP	1991-96	Organic and inorganic fertilization guidelines for Philippine pond conditions	farmers	USAID, Univ. Hawaii, GMIT, UCS, BFAR-NFFRTC
Fishfeeds	1996	Suitable fish feed using local ingredients	farmers feed manufacturers	FFI
Basin approach to environmentally sound management of water resources (Laguna Lake)	Ongoing (5 years)	Management development schemes including policies and regulations	farmers, fisherfolks, aquaculturists, industries	Laguna Lake Development Authority (LLDA)
Laguna Lake primary productivity studies	Continuing	Carrying capacity	Entrepreneurs Extension	LLDA
Survey and assessment of mass fish kills	Continuing	Prevention and control of fish kills	fishers, aquaculturists	LLDA

V. List of On-Going Projects of Aquaculture Development Research Organizations

Project titles	date impl'td	Target beneficiaries	Expected outputs	Participat . Organiz.	Budget
Molecular genetic identification of strains of symbiotic zooanthellae for improved giant clam culture	1995-98	giant clam hatcheries	1. phylogeny of tridacnid zooxanthellae 2. optimal zooxanthellae strains of giant clam mariculture	UP MSI UP IC	Pesos 5 M (I US$ = 26)
Genetic and chemical characterization of Phil agar producing seaweeds as basis for cultivar selection	1992-96	seaweed farmers	publications (identified species with good agar quality and growth rates)	UP MSI	US$ 84,000 (USAID-UNCW)
Development of Gracilaria for open water seaweed farming	1995-98	seaweed farmers	hatchery techniques to culture Gracilaria	UPMSI, BUCI DMNSU, PNAC	Pesos 3 M
Development of germling production and culture technology of sargassum	1995-98	farmers	hatchery and culture techniques	UP MSI	Pesos 913,000
Giant clam research project	1996	farmers	seafarnming of clams	UP MSI NGO LGU	
Dev. of culture technique of *T. gratilla*	1993-97	scientists private entrepreneurs	reseeding of depleted areas	UP MSI	Pesos 1 M
Community-based sea urchin grow-out culture as a resource management tool	1992-97	organized fishers and farmers groups	supplemental source of income; community participation in resource management	UP MSI LGU CD workers	Pesos 600,000

Project titles	date impl'td	Target beneficiaries	Expected outputs	Participat . Organiz.	Budget
Larval rearing of *Scylla serrata*	1996	on-growers	more seed for culture	MSU Inst of fisheries R and D	Pesos 50,000
Identification and control of fungal pathogens of *S. serrata* and *Rana ranina*	1996	extensionists, researchers farmers	advisory to reduce losses from diseases	MSU-IFRD	Peso 25,000
Production and outplanting of Gracilaria sporelings	1996	farmers	materials and methods for culture	MSU-IFRD	Pesos 40,000
Culture of *Therapon cancellatus*	1996	entrepreneurs	techniques for the aquaculture of a new species	MSU-IFRD	Pesos 40,000
Larval rearing of *Anodontia edentula*	1996	farmers	seed for culture	MSU-IFRD	Pesos 40,000
Culture of abalone	1996	entrepreneurs	technology for a new high value aquaculture commodity	MSU-IFRD	Pesos 47,000

VI. List of the Research Organizations Responding to this Survey

1. Institute of Fisheries Research and Development, Mindanao State University (MSU-IFRD)
2. Laguna Lake Development Authority (LLDA)
3. Marine Science Institute, UP at Diliman (MSI-UP)
4. Freshwater Aquaculture Center, Central Luzon State University (FAC-CLSU)

Note: SEAFDEC Aquaculture Department responded to the questionnaire for regional institutions.

Sri Lanka

I. Background

Although aquaculture in Sri Lanka is relatively recent, its importance in providing fish as a cheap source of animal protein to the rural communities, providing income and employment, and earning much needed foreign exchange has been well recognized. In view of the limited production potential in coastal fisheries and high production cost in deep sea fisheries, a high priority has been given to aquaculture development.

The main aquaculture systems are pond farming of shrimps and fish farming in seasonal village tanks. Pond fish culture, cage culture and farming of molluscs, seaweed, etc. are still in the experimental stages. Production from aquaculture in 1994 was 18,000 tons from an area of 52,500 hectares. Some 20,000 people were directly employed in aquaculture.

II. National Aquaculture Development Plan

The Ministry of Fisheries and Aquatic Resources is responsible for planning and implementation of the national aquaculture development plan.

II. 1 Objectives and priorities of the national aquaculture development plan

Aquaculture Development Objectives	Aquaculture Development Priorities
• To increase production of inland fish as a low-cost source of protein for the rural communities. • To increase income and employment opportunities. • To generate foreign exchange	• Inland fisheries and freshwater aquaculture - breeding and seed production of carps • Coastal aquaculture - pen and pond culture of shrimps, crabs and marine fish • Seafarming - testing the economic viability of culture of marine fish, seaweed and molluscs

II. 2 Process followed in formulating the aquaculture development plans and priorities

Aquaculture development plan is a part of overall national fisheries development plan (1995-2000) of the Ministry.

Processes	Criteria	Participants
• Identification of aquaculture resources and potentials • Setting of targets (by the sub-committee of experts) • Review and discussion at public fora	• Availability of aquaculture resources • Potentials for increased production • Potentials for income generation • Potentials for income generation • Foreign exchange earning potential	• Ministry of Fisheries and Aquatic Resources - Aquaculture Development division • Aquaculture Sub-committee • Experts & resource persons • Researchers • Planners • Fishermen's organizations • NGOs • Public

II. 3 Implementation of the national aquaculture development plans

The strategies in implementation of the national aquaculture development plan are:

- Establishment of a separate division for aquaculture development.
- Implementation of alternative seed production programmes.
- Expansion of areas under shrimp cultivation.
- Coastal aquaculture development.
- Diversification of culture species.
- Diversification of culture systems.

Action plans and objectives of the national aquaculture development plan

Action plans	Objectives	Expected results	Target beneficiaries
Rehabilitation of seed production centers	• To increase fry production	• Increased stocking	Rural communities
Stocking of reservoir	• To increase freshwater fish production	• Increased protein supply	Rural communities
Seasonal tank development	• To increase freshwater fish production	• Increased protein fish supply	Rural communities
Integrated fish farming	• To increase income and employment	• Rural development	Rural communities
Coastal aquaculture	• Employment generation and export of production	• Employment for coastal fishermen • Foreign exchange	Coastal communities
Seafarming	• Demonstration of technology	• Increased income for coastal communities	Coastal communities

Changes and emerging issues resulting from implementation of the aquaculture development plan

Action plans	Changes or effects	Issues	Actions required
Rehabilitation of seed production centers	• Availability of fish seed	• Training needs • Marketing of fish seeds	• Community participation • Development of mechanisms for purchase of fingerlings
Stocking of reservoir	• Increased fish production • Increased employment	• Training needs • Marketing of fish	• Strengthening of cooperatives • Organization of villages for fish culture
Seasonal tank development	• Increased fish production • Increased employment	• Training • Marketing of fish	• Organization of villages for fish culture
Integrated fish farming	• Rural development	• Training needs • Coordination with other agencies	• Integrated fish farming (fish, ducks and chickens) • Training
Coastal aquaculture	• Increased foreign exchange • Increased employment	• Environmental problem	• Monitoring of projects
Seafarming	• Awareness creation on seafarming	• Need for technology demonstration	• Training of coastal aquaculturists

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required actions
Administrative and institutional aspect	• Poor coordination among agencies • Lengthy administrative procedures		• Improve coordination among agencies • Improve administrative efficiency
Legal aspects	• Lack of management regulations • Zoning plans		• Establishment and enforcement of regulations
Information	• Technology transfer	• Lack of extension staff	• Recruitment and training of extension staff
Human resources	• Lack of trained personnel	• Delay in recruitment	• Build up a pool of experts • Coordination among agencies
Technical aspects	• insufficient technologies in sea farming, environmental monitoring, disease diagnostics and control, feed development, mass production of seed, effluent treatment	• Lack of proper monitoring system	• Enforcement of regulations
Physical and environment aspects	• Limited land • Pollution of aquatic environment	• Limited area available for coastal aquaculture • Low priority	• Zonation • Coordination among agencies
Socio-economic aspects	• Low price of inland fish • Welfare of inland fishermen • Provision of infrastructure , e.g., housing, roads, drinking water, to rural fishfarming communities	• Low consumer acceptance • Low level of priority given to rural community fishfarming	• Popularization of freshwater fish consumption • Assistance from donor agencies

III. National Aquaculture Development Research

III. 1 Objectives and Priorities of the National Aquaculture Research

The agency responsible for planning and coordination of the national aquaculture research in Sri Lanka is the **National Aquatic Resources Research and Development Agency (NARA).** NARA has the Inland Aquatic Resources and Aquaculture Division that is responsible for aquaculture development and management research.

The function of the agricultural research sector is to carry out research and development activities in relation to biological resources of inland and brackishwater, and development of aquaculture, including environmental assessment and management.

The objectives of the aquaculture research sector are:

- To ensure the application and utilization of scientific and technological expertise for the implementation of national development programmes on aquaculture.
- To promote and conduct research directed towards the identification, assessment, management and development of aquatic resources.
- To coordinate research activities, collection and dissemination of information and training.

List of aquaculture development research priorities

Priority Research Areas	Research Programmes	Expected outputs	Implementing Organiz.	Target beneficiaries	Duration From/To
Shrimp-prawn culture resources management	Disease outbreaks in shrimp culture systems	Management strategies	NARA (CARP; IFS)	Fishfarmers	1993-
	Improvement of farm effluents	Management strategies	NARA	Fishfarmers	1994-
	Use of fauna as indicator organisms to evaluate water quality	Water pollution indicators	NARA	Fishfarmers	1995-
	Control of sulphur reducing bacteria in shrimp farms	Management strategies	NARA	Fishfarmers	1995-
	Coastal zone management - zoning plans for aquaculture	Zoning plan	NARA	Fishfarmers Planners	1995-
Inland aquaculture and inland fisheries management	Development of community-based capture fisheries in reservoirs	Management strategies	NARA Univ. Of Vidyalankaya	Fishing communities	1993-
	Development of technology for larval rearing of freshwater prawn	Improvement of technology	NARA	Fishfarmers	1995-
Seafarming	Development of hatchery technology	Hatchery technology	NARA (CARP)	Fishfarmers	1996-
	Mariculture of sea cucumber	Development of technology	NARA	Fishfarmers Exporters	1996-
Ornamental fish culture	Assessment and management of scientific constraints related to ornamental fish culture	Management strategies	NARA	Fishfarmers	1996-
	Assessment of freshwater ornamental fish resources	Export policies	NARA (CARP)	Fishfarmers	1996-
	Induced breeding of indigenous freshwater fish species	Technology development	NARA	Fishfarmers Planners	1996-
Verification of culture technology	Crab culture	Technology development	NARA	Fishfarmers	1996-
	Community oriented shellfish culture	Technology development	NARA	Fishfarmers	1996-
Mangroves and wetland management	Management of mangrove ecosystem	Conservation and management	NARA	Community Students	1996-

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

Type of organiz.	Processes	Criteria	Participants
National aquaculture research sector, i.e., NARA	• Consultation with farmers, researchers, managers and government officers • Formulation of projects • Discussions with senior staff • Approval of NARA governing council	• Needs of industry • Request of fishfarmers and farm managers • Request of Aquaculture Development Division (ADD) • National development plan	• NARA (ADD) • MOFAR • Fishfarmers, hatchery operators, fishfamers associations • Government extension & development agencies • University researchers •
Research organizations*	• Research proposals prepared for submission for funding • Consultation with government agencies and private sector • Peer consultation	• Research competence • Local & private sector needs • National development needs • Contribution to scientific knowledge • Interests and requirements of funding organizations	• Researchers • University faculty & authority • Government sector (fisheries officers) • Funding agencies

* Five research organizations which participated in this survey are listed in Annex 2.

The National Aquatic Resources Research and Development Agency initiates the priority-setting exercise and formulation of national aquaculture development research plans.

III. 3 National Aquaculture Research Capacity

List of key aquaculture research organizations

Research organizations	Affiliation	Areas of competence
National Aquatic Resources Research and Development Agency	Ministry of Fisheries and Aquatic Resources	• Shrimp culture • Wetland management • Environmental management of shrimp culture • Utilization of problem soils for shrimp culture • Inland fisheries management • Ornamental fish culture
University of Colombo	Ministry of Higher Education	• Bivalve culture • Artemia culture • Prawn culture (ranching in lagoons)
Eastern University	Ministry of Higher Education	• Fish disease • Fish/shrimp farming
Vidyalankara University	Ministry of Higher Education	• Inland aquaculture • Fish diseases • Shrimp culture • Ornamental fish culture • Cultivation of food fish
Department of Animal Science, Faculty of Agriculture, University of Peradeniya	Ministry of Higher Education	• Integrated fish culture • Reservoir fisheries • Rice-fish culture • Fish breeding
Dept. of Fish Biology/Zoology, Univ. of Ruhuna	Ministry of Higher Education	• Resource survey • Fish disease
Rice Research Institute	Ministry of Agriculture	• Rice-fish culture

Adequacy of research capacity in meeting the national aquaculture development needs

National aquaculture development priorities	Priority research needs	Adequacy*
Shrimp and prawn culture	• Environment management	2
	• Disease and health management	2
	• Soil management	3
Inland aquaculture-based capture	• Aquaculture management	1
Fisheries	• Development and improvement of broodstock	2
	• Formulation of low-cost feeds	1
	• Stocking densities in reservoirs	1
	• Integrated fish culture	2
Seafarming	• Verification of technology	2
	• Improvement of breeding techniques	1
	• Economics of seafarming	1

National aquaculture development priorities	Priority research needs	Adequacy*
Ornamental fish culture	•	
	• Breeding of indigenous species	2
	• Environmental aspects - population dynamics	2
Seaweed and mollusc culture	• Improvement of breeding and culture techniques	2
	• Assessment of natural resources	3
Mangrove and wetland management and conservation	• Ecosystem management	2
	• Productivity	2
	• Environmental impact of destruction of sensitive habitats	2
Legal requirements and legislation related to aquaculture	• Improvement of legal framework	1
Socio-economics and environmental impacts related to aquaculture	• Environmental auditing and evaluation	2
	• Studies on social impacts	2

* 1 - no capacity; 2 - inadequate; 3 - adequate; 4 - good; 5 - excellent
(Table continues)

III. 4 Programs of the key aquaculture research institutions

List of the programs of the five key aquaculture research organizations (see VI. List of Organizations)

Priority areas	Objectives	Date imp.
Inland aquaculture; inland fisheries management	• To enhance inland aquaculture production • To develop community-based capture fisheries • To develop culture technology and verification	1996; 1982
Ornamental fish culture	• To promote exotic, endemic ornamental fish culture	
Culture of food fish	• Diversification of culture systems	
Bivalve culture	• Diversification of culture systems	1984
Prawn grow-out culture	• Diversification of culture systems	1995
Artemia culture	• Diversification of culture systems	1988
Sea cucumber culture	• Diversification of culture systems	1996
Integrated fish farming	• To develop sustainable crop-livestock-fish integrated system	1981
Fish breeding and reservoir fisheries	• To increase production and minimize pollution of environment	1990
Fish disease (EUS)	• To study harmful effects of fish EUS	1994
Shrimp/prawn culture and resources management	• To promote shrimp/prawn culture and rational utilization of coastal resources	1982
Seafarming (including seaweed/mollusc culture)	• To undertake resources assessment • To verify technology	1984
Ornamental fish culture	• To develop culture technology • To improve health management • To develop induced breeding of endemic species	1984
Mangroves and wetland management	• To undertake conservation and rational utilization of resources through appropriate management measures	1982

Number of research personnel of the five research organizations by area of specialization

Specialization	Ph D	M Sc	B Sc	Res. Assit.	Total
Biological sciences	26	5	35	32	98
Physical and engineering sciences	10	4	10	30	54
Social sciences	3	1	4	8	16
Economics	4		3	6	13
Legislation					
Others (agriculture, including biology, soil sciences, etc.)	60	22	30	93	205
Total	103	32	82	169	386

III. 5 Dissemination and Utilization of Research Outputs

Target users	Methods used
Policy planners, political level	Reports; Seminars; Newspaper articles
Administrators and managers	Reports; Seminars; Meetings
Fisfarming community	Workshops; Leaflets; Books; Meetings and conferences
Private sector and supporting industries	Meetings; Seminars
Research community	Personal communications; Conferences; Annual seminars; Research papers and abstracts
Extension community	Leaflets; Seminars
Public in general	Newspaper articles

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research

Category	Issues	Constraints	Required Action
Administrative and institutional aspects	• Inappropriate research priority setting • Lack of sound aquaculture research plan • Political interference • Low priority given to research	• political interference • Ad hoc changes in priorities • Ineffective use of funds • Need for trained staff	• Make research organization an independent body • Develop action plan 5-10 years in advance • Prevent political interference • Improve staffing pattern at department level
Legal aspects	• Weakness in legal framework	• Conflicts & problems in implementing plans	• Revise legal framework
Information	• Unavailability of information for research management and planning • Lack of information exchange & coordination • Duplication of projects	• Lack of project information	• Improved flow of information • Improve information exchange and coordination • Develop information facilities (internet) • Acquire current journals • Increased extension and field services
Human resources and research competence	• Lack of trained and experienced personnel		• Promote cooperative programs • Develop regional lead centre for each specific area
Research facilities	• Inadequate research facilities	• Lack of funding	• Provide or develop facilities • Promote collaborative projects • Identify funding sources • Construction of a research laboratory closer to the field site (lagoon)

(Table continues)

Category	Issues	Constraints	Required Action
Research environment	• Duplication of research • Lack of appropriate training and exposure • Lack of farmer participation in research • Lack of coordination • Inability to expand research areas	• Inefficient research management, including implementation and formulation of research program • Low level of education of farmers • Lack of funds • Funds do not reach (or is not available) to research organization	• Develop cooperative research programs, identify main areas of research and allocate sub-areas to different research centres • Recognition of importance of research organizations • Provide appropriate training and exposure for staff • Proper delineation of responsibilities • Improved linkage and cooperation between research, extension and fishing communities

Other suggestions:

- Give more attention to research needs of individual farmers
- Promote the development of lead research centres in main and sub-areas of aquaculture
- Formulate collaborative programmes
- Establish laboratory facilities closer to the lagoon or culture areas
- Information on research programmes and developments should be channeled to research organizations; and appropriate recognition should be given to the work of the organization
- Set up a collaborative arrangement between universities and national research institutions and facilitate integrated approaches in research management

IV. List of On-going Aquaculture Development Projects

Project	Duration From/To	Target beneficiaries	Expected outputs	Participat. organiz.	Budget*
Revitalization of inland fisheries		Fishfarmers	Rehabilitation of aquaculture development centres and increase of seed production	FAO	0.200m US$ .2m (FAO)
Urgent assistance for inland fisheries		Fishfarmers	Increased seed production	ADB	0.30m US$ .54m (ADB)
Mariculture development and training projects		Coastal fishermen	Development of seafarming	German-Sri Lankan bilateral	150.0m
Establishment of freshwater prawn hatchery		Fishfarmers	Development of freshwater prawn farming	as above	60m
Establishment of community-based seed production centers		Fishfarmers	Increased seed production	as above	5.0m
Community-based inland fish production		Fishfarmers	Increased freshwater fish production	JICA	60.0m
Coastal aquaculture and seafarming		Fishfarmers	Development of coastal aquaculture and seafarming	as above	225.0m

* Amount is in SLR rupees unless otherwise indicated.

V. List of on-going Aquaculture Research Projects

Title of Projects	Duration From/To	Target beneficiaries	Expected outputs	Participat. organiz.	Budget (in upees)
Disease outbreaks in shrimp culture system on problem soils	1993-1996	Fishfarmers	• Management strategies	CARP NARA	1.6 m
Improving shrimp farm effluents/receiving water and assessment of farm effluents on secondary productivity	1993-1998	Fishfarmers	• Treatment procedures	NARA	0.5m
Use of benthic fauna as indicator organisms to evaluate the water quality status of Dutch canal	1995-1997	Planners Monitoring organiz.	• Indicators for the assessment of the environment	NARA	0.11m
Control of sulphur bacteria	1995-1997	Fishfarmers	• Management strategies	NARA	0.07m
Development of community-based capture fisheries in selected perennial reservoirs in the dry zone of Sri Lanka	1994-1997	Rural Communities	• Management plan	NARA	0.1m
Development of technology for larval rearing and farming of M. rosenbergii	1995-1997	Fishfarmers	• Technology package and validated technology	NARA	0.25m
Development of hatchery technology for seafarming	1995-1997	Fishfarmers	• Technology package and validated technology	NARA	1.0m
Assessment of management and scientific constraints related to fish diseases in ornamental fish industry	1995-1996	Fishfarmers	• Fish health management strategies	NARA	0.25m
Assessment of freshwater ornamental fish resources in selected areas and building up of a broodstock of fish being bred for export	1995-1996	Planners	• Policies on resources assessment	NARA	0.25m
Experimental induced breeding of selected freshwater fish species of Sri Lanka	1995-1998	Fishfarmers	• Technology package	NARA ARP	0.12m
Economic feasibility of the mudcrab *S. serrata*	1995-1997	Fishfarmers	• Validated technology on mudcrab culture	NARA	0.1m
Community-oriented shellfish culture	1986-1997	Fishfarmers	• Transfer of shellfish culture technology	NARA	0.25m
Introduction of mariculture practices on two currently export-oriented sea cucumber species (*H. Sacarba and H. Atra*) on the northwest coast at Kalpitiya	1995-1997	Fishfarmers Collectors	• Technology package	NARA	0.12m
Management of mangrove ecosystems	1995-1997	Community Researchers	• Management plan	NARA	0.1m
Fish disease	1994-1997	Fishermen	• Identification of causative agents	Eastern Univ.	0.014m
Fish breeding	1990-	Sri Lankans	• Breeding technology for endangered inland fish species	Univ. of Peredeniya	0.10m

Title of Projects	Duration From/To	Target beneficiaries	Expected outputs	Participating organiz.	Budget*
Integrated farming	1987-	Fishfarmers	• Integrated farming system	Univ. of Peredeniya	0.20m US$ 5000 (IFS, Sweden)
Prawn restocking	1995-1996	Fishermen	• Restocking of prawn	Univ. of Colombo	2.5m
Culture of *M. argenelis*	1992-1995	Fishfarmers Rural community	• To develop culture techniques	Vidyalankara Univ. NARESA	0.141m
Culture of snakehead in Muturayawe peaty swamps	1989-	Rural population	• Culture techniques for snakehead	Vidyalankara Univ.	US$ 10,000 (IFS, Sweden)
Efficiency of Preziquantaly as a helmenthicide for *C. melaceskaria* in gills of goldfish raised in mudponds	1993-	Ornamental Fishfarms	• Treatment procedures for parasites in ornamental fish	Vidyalankara Univ.	0.035m
Development of management strategies for Sri Lanka reservoir fishes	1996-1999	Rural communities	• Management strategies for inland aquaculture	Vidyalankara Univ.	0.914m A$ 0.503m (ACIAR)

*Amount in SRL rupees unless otherwise indicated

VI. List of the Research Organizations Responding to this Survey

1. Vidyalankara University of Sri Lanka
2. University of Colombo
3. University of Perdeniya (Faculty of Agriculture, Department of Animal Science)
4. Eastern University (Department of Zoology)
5. National Aquatic Resources Research and Development Agency (NACA)

Thailand

I. Background

Aquaculture and fisheries play an important role in the Thai economy. Thailand is now the seventh largest producer of seafood, with shrimp accounting for about 32% of the total export value. The goal of national fisheries development is to increase fishery production at the rate of 5% a year.

Aquaculture statistics of 1993 showed a production of 3,385,150 tons from 53,224 ha freshwater and 71,887 ha coastal areas. Aquaculture contribution to GDP was 1.4%. Aquaculture directly employed 300,000 people during the year and contributed to 1.4 % of GDP.

The National Inland Fisheries Institute, Department of Fisheries, Ministry of Agriculture and Cooperatives is the agency responsible for planning and implementation of the national aquaculture development plan.

II. National Aquaculture Development Plan

II. 1. Objectives and Priorities of the National Aquaculture Development Plan

The main objective of the national aquaculture development plan is to increase aquatic animal production by aquaculture to satisfy demand for both domestic consumption and export.

National aquaculture development objectives	National aquaculture development priorities
• To increase fish supply for domestic consumption • To improve income of fish farmers • To increase the country's export earning from fish export	• To increase production for export from coastal aquaculture • To support technology for aquaculture • To conduct research for genetic improvement of cultured aquatic animals. • To increase the production from natural water, i.e., reservoirs, rivers and flood areas • To establish centres for technology transfer and training • To solve problems of coastal aquaculture, e.g., disease, environmental concerns, seed production & supply • To build seawater irrigation system and waste water treatment systems • To control price of fish seed and manage seed distribution

II. 2 Process followed in formulating the aquaculture development plans and priorities

Process	Criteria	Participants
Consultative process, following the initiatives of the Department of Fisheries, Ministry of Agriculture and Cooperatives	• National Economic and Social Development Plan	• Office of Fisheries Technical Adviser • Government institutions and divisions concerned with aquaculture

The Office of Fisheries Technical Adviser, Department of Fisheries, Ministry of Agriculture and Cooperatives, initiates the process of setting aquaculture development priorities.

II. 3 Implementation of the National Aquaculture Development Plans

Action plans	Objectives	Expected Results
Developing and improving aquaculture practices through research	To develop management techniques and methods to increase the efficiency of production	• Increase in production
Research for development of new economic species for aquaculture	To develop management techniques and methods to increase the efficiency of production	• Increase in production of new economic species, e.g., oyster, seaweed, mullet fish, artemia, mud crab, squid and sea cucumber, etc.
Improving and regulating the quality standard of aquatic animals by genetic research	To develop management techniques and methods to increase the efficiency of production	• Products meeting international standards • Increase in export
Establishment of standards for hatcheries and aquaculture farms through certification of high standards to registered hatcheries and farms	To develop management techniques and methods to increase the efficiency of production	• Standards and regulations for hatcheries and farms management, especially for marine shrimp
Studies and research of technologies and methodologies for culture and breeding of local aquatic animals and rare species for releasing in natural waters or culture in ponds	To develop management techniques and methods to increase the efficiency of production	• Conservation and biodiversity studies • Culture species diversification
Extension and supporting aquaculture technologies to government staffs and farmers	To develop management techniques and methods to increase the efficiency of production	• Improvement of the production system • High production
Mapping areas that suitable for aquaculture	To facilitate development & regulation	• Control and regulate aquaculture development • Pollution control
Pollution control by fishery laws and regulations, cooperation between government agencies concerned with water quality detection	To protect the environment	• Sustainable use of fishery resources • Sustainable production
Control areas and number of farms for balancing of natural environment • arrangement of coastal aquaculture system • classification of the areas of marine shrimp culture • Registration of shrimp farms and hatcheries	To protect the environment	• Sustainable use of fishery resources • Pollution control
Support to Department of Fisheries to in control and regulate use of chemotherapeutants in aquaculture • Animal food law 2525 B.E. • Research on effects of medical/chemical used in aquaculture	To protect the environment	• Standards and regulations • Pollution control
Assessment of environmental effects of industrial aquaculture	To protect the environment	• Standards and regulations • Pollution control and management
Water use management and support for infrastructure development	To develop and support infrastructure	• Infrastructure development • High production
Rehabilitation of natural canals and rivers	To develop and support infrastructure	• More water for aquaculture • High production
Support to the soft loan project for aquaculture	To develop and support infrastructure	• Expand aquaculture • Increase production
Establish cooperation between institutions concerned with the improvement of infrastructure, e.g., road, electricity , tape water etc.	To develop and support infrastructure	• Improved infrastructure • Increased production
Support factors for production, e.g., fish seed, fertilizers and fishfeed to farmers especially those that suffer from calamities like floods.	To develop and support infrastructure	• Improved culture systems • Increased production

Action plans	Objectives	Expected Results
Support the establishment of fish seed production centre in every village, as needed	To develop and support infrastructure	• Available fish seed • Decreased production cost
Support for establishment of water supply systems for aquaculture	To develop and support infrastructure	• Increased water supply • Decreased in production cost
Support commercial scale aquaculture	To develop and support infrastructure	• Improved culture systems • Increased in production
Activate concerned government agencies which arrange to use public land for aquaculture and cut off the process of using public land for aquaculture	To develop and support infrastructure	• Increased production areas • Increased in production
Identification and study of the breeding areas of aquatic animals	To develop and support infrastructure	• Increased seed supply • Increased production
Establish the central market of aquaculture product	To develop and support infrastructure	• Higher price of aquaculture products • Balanced demand and supply
Appoint fishery attaché in important importing countries to promote Thai fishery products	To develop and support infrastructure	• Increased volume and value of fishery export s • Increased export earnings
Support development of fish farmers co-operatives	To develop and support infrastructure	• Control price of aquaculture products • Higher price of aquaculture products
Development of fishery data analysis system and information services to fish farmers	To develop and support infrastructure	• Increased production • Balanced of demand and supply

Changes and emerging issues resulting from implementation of the aquaculture development plans

Action plans	Changes/effects	Emerging Issues	Actions required
All action plans (see above)	Increased aquaculture production and development of aquaculture systems	• Disease identification and control • Ornamental fish production	• Disease diagnostic facilities and units • Support for ornamental fish production for export

Critical aquaculture development needs that are not addressed by existing aquaculture development programs and projects:

- Aquatic animal disease control - (1) more equipment and more clinics which can provide diagnostic facilities for farmers; (2) research on developing new methods which can help in the development of rapid diagnostic facilities.
- Ornamental fish production for export - the government should respond to the need for research on and promotion of ornamental fish and other aquatic animals, including the provision of trade and investment support to the private sector.

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required action
Administrative & institutional aspects	• Lack of cooperation among related agencies	• Culture and tradition	• Improved coordination • Re-orientation & training of staff
Legal	• Overlapping jurisdictions	• Too many government departments and agencies are concerned with aquaculture	• Review of fisheries laws and regulations
Information	• Ineffective technology transfer • Poor technology transfer	• Reluctance of many researchers to present their results	• Change in the system of promotion • Improve extension work
Human resources	• Lack of skilled personnel	• Insufficient number of scientists in aquaculture	• Recognition and promotion for aquaculture specialists
Technical	• Lack of management guidelines		• Evolve management guidelines
Physical and environmental	• Pollution and environmental factors	• Rapid increase of industrial areas	• Improvement & enforcement of environmental laws and regulation
Socio-economic	• Low price of aquaculture products • Difficulty in recruiting workers	• Indirect market, i.e. many middlemen • Low wages for physical work	• Improvement of government in marketing of products • Use of foreign workers

III. National Aquaculture Development Research[5]

The Office of Fisheries Technical Adviser is responsible for coordinating national fisheries and aquaculture development researches.

III. 1 Objectives and Priorities of the National Aquaculture Development Research

Objectives of Aquaculture Development Research	Priority Research Areas
• To undertake research in support of national aquaculture development and assist in establishing aquaculture as an economically viable industry	• Tiger prawn culture • Brackishwater fish culture • Fish genetics • Freshwater prawn culture • Fish breeding and culture systems • Fish nutrition and feed • Freshwater fish culture • Fish toxicology and fish disease • Oyster culture • Seaweed culture

[5] The agency responsible for coordination of national aquaculture development research did not responded to the survey. Information in this section was supplemented from the national report on "Aquaculture Development Research Priorities and Capacities in Thailand" prepared by NIFI, information brochures of the Department of Fisheries, and presentation made by Mr. Pinit Sihapitukgiat at the Regional Workshop on Survey and Analysis of Aquaculture Development Research Priorities in Asia, held in Bangkok, Thailand on 21-23 May 1997.

Aquaculture development research needs are:

- The problems of environmental impacts and sustainability of aquaculture
- Improved culture technologies and systems
- Fish nutrition
- Fish disease control and prevention
- Genetic improvement of fish stock
- Quality of seed and brooders
- Quality of fishery products

III. 2 Processes and Criteria Used in Formulating Aquaculture Research Plan and Priorities

Type of organization	Process	Criteria	Participants
Department of Fisheries, Ministry of Agriculture and Cooperatives	• Central initiatives, followed by consultation with related development and research agencies	• National Economic and Social Development Plan # 7 and # 8 • National aquaculture development needs	• Office of Fisheries Technical Adviser • Institutions and divisions that are concerned with aquaculture
Research organizations (five academic institutions responding to the survey)	• Individual initiatives in preparing research proposals • Peer reviews	• Farmers' or local needs • Scientific merits and contribution to scientific knowledge • Area of competence • National development needs	• University & Faculty • Funding agency

III. 3 National Aquaculture Research Capacity

List of key aquaculture research organizations

Research organizations	Affiliation	• Areas of competence
Freshwater Fisheries Division	Ministry of Agriculture and Cooperatives	• Freshwater fish culture
National Inland Fisheries Institute	Ministry of Agriculture and Cooperatives	• Freshwater fish culture
Coastal Aquaculture Division	Ministry of Agriculture and Cooperatives	• Coastal aquaculture
National Institute of Coastal Aquaculture	Ministry of Agriculture and Cooperatives	• Coastal aquaculture
Phuket Marine Biological Centre	Ministry of Agriculture and Cooperatives	• Fish biology
Feed Quality Control and Development Division	Ministry of Agriculture and Cooperatives	• Feed quality control & development
Aquatic Animal Health Research Institute	Ministry of Agriculture and Cooperatives	• Fish health control and management
National Aquaculture Genetic Research Institute	Ministry of Agriculture and Cooperatives	• Fish genetics
Institute of Marine Science, Burapha University	Ministry of University Affairs	• Fish biology; Feed development
Dept. of Fisheries Technology, Maejo University	Ministry of University Affairs	• Freshwater aquaculture; Environmental management; Fish genetics and breeding

Research organizations	Affiliation	• Areas of competence
Faculty of Fisheries, Kasetsart University	Ministry of University Affairs	• Breeding; Culture; Nutrition; Genetics; Health management; Environmental management; aquaculture management
Dept. of Fisheries, Khon Kaen University	Ministry of University Affairs	• Breeding; Nutrition; Biology; Water quality management
Dept. of Biochemistry, Prince of Songkla University	Ministry of University Affairs	• Nutrition and feed; Intensive shrimp farming system; Physiology

Adequacy of research capacity in meeting the national aquaculture development needs

Thailand is one of the main aquaculture producers in the world. It has reasonable research capacity to address many aquaculture development needs. However, research capacity in shrimp/prawn broodstock management and disease diagnostics requires some improvement.

III. 4 Programmes of the Key Aquaculture Research Institutions

List of the aquaculture research programmes of the five research organizations (see item VI for the list of organizations)

Programmes	Objectives	Date Implemented
Development of sustainable black tiger shrimp culture	• To develop technology on hatchery and grow-out ponds, with emphasis on farm management, health management, genetics and nutritional approach	1996-2000
Management of natural resources of freshwater and marine aspects	• To study aquatic animals population of water reservoirs • To study environmental impact assessment of water resources • To study marine resources management in terms of aquatic animal population	1996-1998
Development of potential aquaculture for economic aquatic animals and plants	• To study the problems that retard the development of potential species for aquaculture • To identify new and potential species of aquatic animals and plants	1996-1999
Genetic approach for the development of new strains and species	• To apply genetic technology to some economic species	1992-
Development of diets for aquatic animals using low-cost ingredients	• To develop low-cost feeds for fish	
Mountain frog culture	• To identify potential species for culture	1996-
Rearing techniques for seashores in natural conditions	• To develop culture techniques for seashores in laboratory and natural conditions	1986-1989
Hatching and nursing of swimming crab in earthen ponds	• To develop nursing techniques for mass culture of swimming crabs in earthen ponds	1993-
Use of aquatic organisms for water reconditioning in closed recirculating seawater system	• To study the optimum density of seabass in recirculating seawater system	1994
Feed formulation for banana prawn	• To produce suitable feed for prawn	
Behavioral studies on banana prawn	• To determine the optimal amount and feeding regimes for banana prawn	1994-1997
Physical factors affecting growth and survival	• To determine the optimal salinity for growth and survival	

Number of research personnel of the five research organizations and the Department of Fisheries by area of specialization

Specialization	Ph D	M Sc	B Sc	Res. Assist.	Total
Biological sciences	53	160	320	221	754
Physical and engineering sciences					
Social sciences		4	4	47	55
Economics		5	7	1	13
Legislation			1	2	3
Others					
Total	53	169	332	271	825

III. 5 Dissemination and Utilization of Research Outputs

The five research organizations reported that research outputs are disseminated through training courses, newsletters, technical papers, journal publications, seminars, newspapers, and radio and TV.

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Research

The five research organizations have identifies the following issues and needs in planning and implementing their programs.

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Low priority given to research • Lack of funds & support • Lack of coordination and collaboration among related organizations and overlap in research activities	• Budgetary constraints • Organizational structure & procedures are not appropriate for management of rapidly expanding aq. sector • Concentration of research on one area excludes/limits activities in other areas • Main function of institution is teaching	• More support for research • Institutional development and linkages, including coordination of research programmes at the central level and designation of coordinator of each particular research field • Development of broader research vision • Identify research funding sources (government, state enterprise or private sector)
Legal aspects			
Information	• Ineffective and inadequate access to external information • Weak technology transfer (see human resources below)		• Promote & establish regional aquaculture information exchange network • Strengthen technology transfer, including technology validation • Coordination among extension, research and farming communities
Human resources and research competence	• Lack of skilled personnel • Lack of training in aquaculture, e.g., extension staff and technicians are trained in agricultural colleges	• Inexperienced young scientists • Early stage of development of organizations • Government policy on limiting new positions	• Training courses, further studies and study tours • Budgetary allocation for training • Policy change allowing hiring of research personnel
Research facilities	• Lack of equipment and facilities • Lack of field laboratories	• Early stage of development of many research organizations	• Establishment of field laboratories, appropriate aquarium and analytical laboratories

Category	Issues	Constraints	Required Actions
Research environment	• Lack of incentives and/or low moral • Lack of interest in field research in rural areas • Lack of on-farm research	• Most scientists are occupied with work for private sector or in commercial areas • Lack of recognition and rewards for on-farm and field research • Teaching overload	• Policies and incentive schemes to recognize on-farm and field research in rural areas • Provision of supplementary income or honorarium • Fewer course (teaching) assignments

Other suggestions by the research organizations:

- A communication and/or database that will prevent duplication of research or provide information on such things as research committees on each research issue, ex., for black tiger shrimp, for which commodity such a committee exists. The committee has developed research guidelines and gives grants but very few researchers know this.
- Need for new and capable researchers to be involved in [the development of] research policies critical to the research program.
- Need for linkages with NACA and other countries on aquaculture research.
- Nature of research topics requires well-trained staff in addition to laboratories, experimental stations and collaboration with the private sector.

IV. List of On-Going Aquaculture Projects of Aquaculture Development Agency

Projects	Date impl't ed	Target beneficiaries	Expected outputs	Implementing organizations
Development of management techniques and improved aquaculture methods				
Developing and improving methods of aquaculture	1993	Fishfarmers	Increased production	• DOF & OAE • Academic institutions
Development and research on new economic species for aquaculture	1993		Increased production	• DOF • Nat. Research Council • Academic institutions
Improving and regulating quality standards of aquatic animals by genetic research	1993		More export products	• DOF • Academic institutions
Establishment of standards for hatcheries and aquaculture farms	1993		Certificates given to high standards registered hatcheries & farms	• DOF • Shrimp farm associations • Private sector
Development of technologies and methodologies for culture and breeding of local aquatic animals and rare species	1993		To protect & conserve rare species and useful local species	• DOF • Academic institutions
Extension and supporting aquaculture technologies to government staff and farmers	1993		High production	• DOF • Academic institutions • Aquaculture associations
Mapping areas suitable for aquaculture	1993		Pollution control	• DOF • Provinces concerned • Office of Environ. Planning
Environmental protection				

Projects	Date impl't ed	Target beneficiaries	Expected outputs	Implementing organizations
Pollution control through fishery laws and regulations	1993		Sustainable use of fishery resources	• DOF • Provinces concerned • Dept. of Forestry • Dept. of Environ. Quality Extension • Shrimp farm associations
Balancing the natural environment by controlling areas and number of farms	1993		Pollution control	• DOF • Office of Environ. Policy and Planning
Control and regulation of the use of drugs and chemicals used in aquaculture	1993		Pollution control	• DOF • Dept. of Industrial Control • Ministry of Pub. Health
Support of the recommendations of the report on environmental effects of industrial aquaculture	1993		Pollution control and management	• DOF • Dept. of Environ. Quality Extension
Development of and support for infrastructure for aquaculture				
Water use management and other factors (ex., funding)	1993		High production	• DOF • Dept. of Water Irrigation
Rehabilitation of natural channels and rivers	1993		High production	• DOF • Dept. of Water Irrigation
Support of project on soft loans for aquaculture	1993		Increased production	• DOF • Financial agencies
Building up cooperation between institutions concerned with the improvement of infrastructure	1993		Increased production	• DOF • Ministry of Transp. • Dept. of Water Irrigation • Provinces concerned
Support of production factors,	1993		Increased production	• DOF • Ministry of Interior
Establishment of fish seed production centers in every village	1993		Lower production costs	• DOF • Provinces concerned
Provision of water supply system for aquaculture	1993		Lower production cost	• DOF • Dept. of Water Irrigation
Support for commercial-scale aquaculture	1993		Increased production	• DOF • Private sector
Development of more areas for aquaculture (through discussion with concerned government agencies) by using public land for aquaculture	1993		Increased production	• DOF • Dept. of Forestry
Studies on the breeding areas for aquatic animals	1993		Increased production	• DOF • Provincial fishery officers concerned
Establishment of a central market for aquaculture products	1993		A balanced supply and demand situation	• DOF • OAE • Dept. of Internal Comm. • Private sector
Designation of a fishery attaché in important importing countries to look after and promote fishery products	1993		Increased national income	• DOF • Ministry of Foreign Affairs • OAE

Projects	Date impl't ed	Target beneficiaries	Expected outputs	Implementing organizations
Support for the establishment of fishfarmers' cooperatives	1993		Higher price of aquaculture products	• DOF • Private sector
Development of a system of fishery data analysis and information service for fishfarmers	1993		Achievement of a balance in supply and demand	• DOF • OAE • Ministry of Commerce

V. List of On-going Projects of Main Aquaculture research organizations

Title of Projects	Duration From/To	Target benefic-iaries	Expected outputs	Implement organiz.	Budget (in Baht)
Development of techniques for intensive farming of banana prawn			Intensive farming of economicall y important prawn	Prince of Songkhla Univ.	4.9m
Biology of Thai northeast native and introduced aquatic animals of economic value	1995-1996			KKU	0.386
Biology and culture systems of freshwater rotifer, water flea and brine shrimp	1995-1996			KKU	0.070
Preliminary study on culture of river barb(*Cyclocheilichthys* sp.)	1995- 1997			KKU	0.050
Effects of salinity on growth and survival rates for walking catfish larval rearing and its culture: Implications on saline soil area	1995-1996			KKU	0.080
Utilization of economic crops to decrease soil fertility in fishponds	1995-1996			KKU	0.075
Study on growth of the three-spotted gourami fed with various artificial feed	1995-1996			KKU	0.080
Studies on age and growth of climbing perch from scales and otoliths	1996-1997			KKU	0.0997
Comparison of walking catfish hematology rearing at various saline water: Implications for fish culture in saline soil area	1996-1997			KKU	0.0994
Study on the effects of estradiol (EST) and diethylstilbestrol on inducement of sex reversal in female sepat siam	1996-1997			KKU	0.1495
Preliminary study on culture of river barb (*Cychocheilichthys* sp.)	1996-1997			KKU	
Fisheries potential research and development on saline soil in Northeast Thailand	1996-97			KKU	0.143
Study on effect of photoperiod and temperature on gonadal recrudescence of *Clarias macrocephalus*	1995-97			Kasetsart Univ	0.400
Management and detoxification of metabolites in marine shrimp ponds	1995-97			Kasetsart Univ	4.685
Improved use of artemia technology on integrated shrimp and fish farming	1996			Kasetsart Univ	0.400
Culture of economically important micro-algae	1995-96			Kasetsart Univ	1.309

Title of Projects	Duration From/To	Target benefic-iaries	Expected outputs	Implement organiz.	Budget (in Baht)
The use of artemia in fish and shrimp hatchery and potential areas for artemia production in Thailand	1995-96			Kasetsart Univ	
Species diversity of free living marine nematodes in shrimp culture ponds in Thailand	1995-97			Kasetsart Univ	
Preservation of natural colour and quality of dried shrimp	1996			Kasetsart Univ	
Research on environmental and socio-economic impact of the farming of tiger prawn in freshwater areas	1996			Kasetsart Univ	0.700
Rearing of seahorse in laboratory and in natural ponds			Culture techniques for seahorse	Burapha Univ.	0.050
Development of sustainable black tiger shrimp culture	1996-2000		Technology on hatchery and grow-out ponds	DOF MiOAC	
Management of natural resources of freshwater and marine aspects	1996-1998		Fishery policies on managemen t of natural resources		
Development of potential aquaculture for economic aquatic animals and plans	1996-1999		Identification of potential new species of aquatic animals and plans		
Genetic studies: Development of new strains of species	1992-		Improved production		
Development of diets for aquatic animals using low-cost ingredients	1995-		Low-cost feed formulas		
Mountain frog culture	1996-1997	Local farmers	Evaluation of potential species for aquaculture	Maejo Univ.	0.200

VI. List of the Research Organizations Responding to this Survey

1. Department of Fisheries Technology (Faculty of Agricultural Production), Maejo University
2. Department of Aquaculture (Faculty of Fisheries), Kasetsart University
3. Institute of Marine Science, Burapha University
4. Department of Fisheries (Faculty of Agriculture), Khon Kaen University (KKU)
5. Department of Biochemistry (Faculty of Sciences), Prince of Songkhla University

Viet Nam

I. Background

In Vietnam, aquaculture has significant socio-economic benefits. Aquaculture contributes about 30-40% of total fish production, which in turn contributes about 50 % (equivalent to US$ 260 million) of total exports of the fishery sector in 1995. Aquaculture has offered opportunities for employment and income in rural and coastal communities, and associated industries such as processing and feed supply. Fisheries, including aquaculture, contributes 9% to GDP.

Aquaculture is carried out on all types of water bodies, covering all possible species and utilizing different technologies. For freshwater aquaculture, the primary focus of the government policy is on increasing supply of fish protein for domestic consumption through integrated aquaculture, development of cage culture and enhancing stocks in rivers and reservoirs, and increasing rice-fish culture. For coastal aquaculture, the policy is focused on increasing production of export commodities through emphasis on shrimp and crab culture, marine cage culture of high-value species such as grouper, seabass and yellowtail, mollusc culture, and seaweed culture.

Aquaculture statistics indicates that total aquaculture production was 380,000 tons in 1994, from a production area of 568,000 hectares. About 350,000 people are directly employed in aquaculture.

II. National Aquaculture Development Plan

II. 1 Objectives and priorities of the national aquaculture development plan

Aquaculture Development Objectives	Aquaculture Development Priorities
• To achieve high production to meet domestic and export demands • To generate employment opportunities • To achieve sustainable aquaculture in combination with resource management and environmental protection • To strengthen industrialization and modernization of aquaculture	• Production of healthy shrimp seed • Production of feed for cultured aquatic animals • Disease prevention and control • Environmental management • Policies and regulations - national and local policies; aquaculture legislation

II. 2 Process followed in formulating the aquaculture development plans and priorities

Processes	Criteria	Participants
Central government initiative	National development needs (e.g., national need for seed)	• Various departments of the Ministry of Fisheries • Research Institute for Aquaculture 1, 2 and 3; Research Institute for Marine Products • Government and private hatcheries • Private sector

The Department of Planning and Investment, Ministry of Fisheries is the agency responsible for planning and coordination of the national aquaculture development plan. The Department of Science and Technology, Department of Fishery Management and Department of Resource Protection, Ministry of Fisheries are the agencies responsible for

fisheries management policies and legislation, technology development and management, implementation of fishery extension and protection of environment and natural resources.

II. 3 Implementation of the National Aquaculture Development Plans

The strategies used to implement the national aquaculture development plan are:

- Sustainable development, in combination with protection of resources and the environment, disease prevention and control, and economic development.
- Use of the family unit as active economic units, the family being the main force in aquaculture. State enterprises assume a major role in the provision of services and materials.
- Increased investment in coastal and rural zones.
- Increased rate of aquaculture development within the fishery sector.
- Market development and production links with processing and consumption points.
- Conduct of more applied research.
- Adoption of advanced technologies from other countries to increase production.

Action plans and objectives of the national aquaculture development plan

Action plans	Objectives	Target beneficiaries	Expected results
Crustacean culture	• To cultivate an area of 460,000 hectares and to produce 191,000 tons	Fishfarmers	• An increase in intensive culture of crustacean (50-60%) and semi-intensive culture by 20-30%
Fish culture	• To achieve a production area of 57,300 hectares and produce 711,000 tons.	Fishfarmers	• Development of high-value species for culture
Aquatic animals program	• To produce for export 6000 tons	Fishfarmers	• Culture of frogs, turtle, ornamental fish and other aquatic animals for export and to supply needs of population
Seed production	• To produce 19 billion shrimp fry, 6-8 billion of fish fry and 30-40 million of mollusc fry	Fishfarmers	• Sufficient seed supply to meet national demand.
Environmental protection and disease control	• To protect the environment • To prevent disease • To produce chemicals and drugs for fish diseases	Fishfarmers	• Disease prevention and sustenance of environment
Seaweed culture	• To attain a production area of 130,000 hectares • To produce seaweeds for export	Fishfarmers	• Increased exports
Fish cage culture	• To supply seed (about 1500 MT)	Fishfarmers	• Improved living conditions of rural population

Changes and emerging issues resulting from implementation of the aquaculture development plans

Action plans	Change or effect	Issues	Required action
Crustacea culture	• Widespread development of shrimp culture • Increased production	• Supply of broodstock, shrimp seed and crab juveniles • Disease and environment • Budget allocation • Feed supply	• Studies on broodstock, healthy fry, disease prevention • Establishment of policy on allocation of funds
Fish culture	• Development of facilities and technologies for seed production • Development of techniques in	• Degradation of genus • Cage culture fish disease • Seed supply for marine	• Studies on disease prevention and cure • Artificial seed

Action plans	Change or effect	Issues	Required action
	freshwater fish culture • Initiation of marine fish cage culture & brackishwater culture	cage culture	production for grouper, amberjack, seabass • Selection of genus
Mollusc culture	• Culture of pearl oyster and mollusc	• Land use policies • Export and processing • Seed production	• Study on Seed production • Marketing • Land use policy - zoning
Culture of special aquatic animals for export	• Development of high economic value products for exports • Improved living condition of rural community	• Seed supply • Lack of production capital • Feed supply	• Seed production technologies • Establish production credit system
Aquaculture extension	• Increased farmers' knowledge on aquaculture technologies	• Lack of culture technology models	• Development of culture technology models
Formulation of policies and regulations	• Stabilized aquaculture sector • Planned sector development		• Dissemination of aquaculture policies and regulations

II. 4 Issues and Needs in Formulating and Implementing National Aquaculture Development Plans

Category	Issues	Constraints	Required action
Administrative and institutional aspects	• Uncoordinated expansion of aquaculture in coastal areas • Uncoordinated planning	• Lack of cooperation among responsible organizations in formulating plans & policies	• More [effective] leadership • Dialogue between and among the fisheries, agriculture and irrigation sectors
Legal	• Late issuance of some legal codes & regulations	• Lack of legal personnel at state agencies	• Train more legal staff in state agencies
Information	• Ineffective and inefficient transfer of technology • Lack of modern means of information dissemination	• Lack of information & extension facilities • Incomplete information & extension organization	• Increase investment on facilities. • Develop information network linking related institutes, organizations, universities and local offices.
Human resources	• Lack of skilled persons and experts in aquaculture • Weak problem solving capacity	• Lack of training opportunities • Low pay in the public sector	• Improve training programs • Improve dialogue and partnership between research community and farming community
Technical	• Lack of culture technologies & models for different ecological regions	• Diversity of ecological zones • Low level of technology management	• Studies on biology and culture techniques for each ecological zone • Exchange of experts
Physical and environmental	• Lack of EIA in construction of farms and establishment of culture zones	• Lack of planning & zoning in development of coastal aquaculture	• Planning in establishing culture zones. • Improve technology for farm construction
Socio-economic	• Lack of credit • Limited market mechanism	• Limited funds • Difficulty in obtaining credit	• Establish credit systems • Improve procedures in obtaining credit

III. National Aquaculture Development Research

III. 1 Objectives and priorities of the national aquaculture development research

The Department of Science and Technology of the Ministry of Fisheries is the agency responsible for planning and implementing the national aquaculture development research pans and programs.
The main functions of research organizations are:

- To undertake aquaculture development research
- To study the interaction between environment and aquaculture for purposes of protecting the environment and ecosystems
- To develop artificial breeding technology for species in areas with varying ecosystems
- To study the proper use of land, water ad fisheries resources, environmental protection and sustainable aquaculture development
- To adopt and improve foreign technology and evolve new technologies that are suitable for conditions in Vietnam
- To disseminate research findings
- To make policy recommendations on the management of science and technology and industrial copyrights

Aquaculture development research priorities and action plans/programmes

Priority Areas	Duration	Expected Outputs	Target beneficiaries	Implementing organizations
Artificial seed production		• Higher seed production and reduction of natural seed exploitation	Fishfarmers	• Research Institute for Aquaculture • Univ. & colleges • Local exp. stations
Models and species suitable for geographic and ecological conditions of each area		• Increased productivity and selection of suitable species for culture		• Research Institute for Aquaculture • Univ. & colleges • Local exp. stations
Environment and fish disease		• Sustainable environmental protection • Solution to disease problems • Increased productivity • Improved quality of cultured fish		• Research Institute for Aquaculture • Univ. & colleges • Local exp. stations
Fish genetics	1996-1998	• Preservation of gene pool • To produce monosex of tilapia		• RIA No. 2 • RIA No. 1
Fish and shrimp disease:	1996-1999	• Development of preventive and control methods		• RIA No. 2 • AAHRI •
Hatchery	1996-1997	• Propagation of seabass • Propagation of river catfish		• RIA No. 2 • MOF
Processing	1996-1998	• Processing technology		• RIA No, 2 • NIF
Giant prawn aquaculture	1994-1997	• Technology transfer in the Mekong Delta		• RIA No. 2
Natural resource management	1996-1997	• Better management and improvement of wetland fish production		• RIA No 2 • MOF
Artemia production	1996-1998	• Development of technology		• RIA No. 2

Priority Areas	Duration	Expected Outputs	Target beneficiaries	Implementing organizations
		for artemia salt		• MOF
Research and experimental farming of some imported shrimp and fish species		• Increased productivity and yield	Fishfarmers	• Research Institute for Aquaculture • Univ. & colleges • Local exp. stations

III.2 Processes and Criteria Used in Formulating Aquaculture Research Plans and Priorities

Type of organization	Processes	Criteria	Key participants
National aquaculture research sector	Consultative process: Collect information from farmers	• Farmers' needs • National development needs • Regional development needs	• Farmers • Research institutes • Universities • Provincial experiment centres • Extension centres • Associations and service companies
Research organizations	Consultative	• Farmers' needs • Local needs and requirements • National development objectives • Availability of resources • Research interest • Private-sector funding	• Faculty • Farmers • Local governments • Regional and international • RIA Scientific Council

III. 3 National Aquaculture Research Capacity

List of key aquaculture research organizations

Research organization	Affiliation	Area of competence
Research Institute for Aquaculture No. 1	Ministry of Fisheries	• Freshwater aquaculture • Fish diseases
Research Institute for Aquaculture No. 2	Ministry of Fisheries	• Seed production and giant prawn commercial production • Marine fisheries • Marine seed and shrimp production • Environment and fish disease
Aquaculture Research Centre No. 3	Ministry of Fisheries	• Marine seed production • Shrimp commercial farming • Mollusc and seaweed culture
Research Institute for Marine Products	Ministry of Fisheries	• Seed production • Shrimp, fish and seaweed culture
Information Centre for Fisheries Economics and Science and Technology	Ministry of Fisheries	• Scientific and economic information of the whole fisheries sector

Adequacy of research capacity in meeting the national aquaculture development needs

National aquaculture development priorities	Priority research needs	Adequacy
Shrimp farming development	• Water sources and water quality management • Breeding broodstock & Seed production • Feed production for shrimp farming • Disease control and prevention • Selection of suitable farming models for each ecosystem	
Seed production and marine fish culture of species with high export value	• Artificial seed production • Feed production • Cages and net system in farming locations	
Marine crab culture	• Seed production • Selection of best suitable model • Feed for crab • Disease control	
Sex reversal of tilapia by industrial method	• Seed production • Procedures for commercial production • Disease control	
Imported fish species with high economic value	• Domesticating • Experimental farming • Seed production at suite • Selection of suitable farming models • Farming procedures and disease control	
Asiatic soft shell turtle farming for export	• Seed production • Technology for commercial farming • Feed production for commercial farming • Disease control	

III. 4 Programs of the Key Aquaculture Development Research Institutions

The objectives of the six research organizations (see appendix 2 for the list of the organizations) are:

- To study models of aquaculture (shrimp, crab, mollusc, fish, seaweed)
- To study seed supply (shrimp, crab, mollusc, grouper)
- To study aquaculture and the environment, including disease

Priority areas	Objectives	Duration From/To
Environment and natural resources management		
Mariculture		
Freshwater aquaculture		
Shrimp seed and culture	To ensure sufficient supply of seed To develop culture models	1991-
Crab culture	To ensure sufficient seed supply To develop culture know-how	1991-95
Fingerlings and supply of marine fish	To develop seed culture	1991-96
Seaweed culture	To develop culture technology	1991-
Transplantation and acclimatization of fishes	To increase fish production	1985-
Gene pool preservation of freshwater fishes	To preserve the pure lines of main culture fish species	1985-
Improvement of fish seed quality	To increase productivity	1990-
Prophylaxis and therapy of fish and shrimp in freshwater and brackishwater areas	Disease treatment and prevention	1985-
Seed and culture of shrimp	To produce more seed and gain more knowledge on aquaculture	1985-90-
Artemia culture	Mass production of cyst	1985-90

Priority areas	Objectives	Duration From/To
Seed production and culture of scallop	To ensure sufficient seed supply and increased production	1991-95
Lobster seed supply and culture	Development of technology for lobster production	1991-95
Seed production and pearl culture	To develop seed production and culture technology for pearls	1996-2000
Study on natural resource of lobster	Production technology	1996-2000

Number of research personnel by area of specialization

Specialization	Ph D	M Sc	B Sc	Res. Assist.	Total
Biological sciences	27	19	221	43	310
Physical and engineering sciences	7		15		22
Social sciences		1	6		7
Economics			1		1
Legal studies			2		2
Other (various fields)	1		23	55	79
Total	35	20	268	98	421

III. 5 Dissemination and Utilization of Research Outputs

Target audience	Methods used
Policy planners	Technical manuals; Workshops; Conferences; Reports; Seminars
Administrators and managers	Technical guides; Documents; Regular meetings (six-month intervals)
Private sector/supporting industry	Technology transfer (application of research results); Television and radio; Leaflets; Field visits; Demonstration farms; Training; Technical assistance Study tour
Fishfarming community	Technology transfer (application of research results); Reports; Student-private sector cooperative projects
Research community	Verification of technology; Publications; Workshops; Scientific papers (publication)
Extension community	Technology transfer; Leaflets; Video cassettes; Training; Meetings and workshops
Public in general	Technology transfer; TV and other media

Research organizations reported that research outputs are disseminated through implementing the research projects in farming localities to enable the immediate transfer of the technologies to the farmers and direct transfer of technology to local authorities. However, it also acknowledges that the task of technology transfer should rightfully be done by a technology transfer centre. One research organization said that its research outputs are disseminated through fisheries extension activities of the government, NGOs and international projects.

III. 6 Issues and Needs in Planning and Implementing National Aquaculture Development Research

Category	Issues	Constraints	Required Actions
Administrative and institutional aspects	• Lack of proper coordination among related agencies	• Lack of coordination mechanisms	• Improve management procedures
Legal aspects			
Information	• Inefficient delivery mechanisms of information • Lack of information exchange • Lack of information	• Limited knowledge of staff • Weak knowledge of foreign language • Lack of information resources • Lack of funds	• Training • Strengthen foreign language skills • Strengthen information exchange • Coordination with National Information Institute
Human resources and research competence	• Lack of skilled personnel	• Inadequate level of training & knowledge • Older personnel have not completed their training	• Provide local and foreign training • Strengthen younger staff with complete training
Research facilities	• Inadequate & old equipment • Lack of research facilities	• Limited investment in research facilities • Lack of funds for research	• Acquire more equipment, replace old ones • Increase budget for research
Research environment	• Underutilization of research findings	• Lack of awareness of farmers on research results	• Organize more training courses for fishermen

Other suggestions:

- Development of collaborative projects with other regional aquaculture organizations
- Promotion of sharing of experiences and information and technology with other countries
- Improvement of research facilities through assistance of international organizations
- Establishment of an information exchange system with regional programs

IV. List of On-Going Projects of Aquaculture development agency

Projects	Duration From/To	Target beneficiaries	Objectives	Implement. organiz.	Budget (in VN dong)
Shrimp seed supply for the North	1995-1996	Farmers	Network of seed supply in the north	• RIMP • Local offices	400 m
Crab seed production and culture	1991-1996	Farmers	Development of technology	• RIMP • RIA No. 3 • Local fishery office	400m
Production of seed of high economic value (mollusc)	1991-to date	Farmers	Supply of mollusc seed for industrial culture	• RIMP • RIA No. 3 • CAC	
Production and culture of mollusc	1970-1995	Farmers	Development of technology	• RIMP • RIA No 3 • CAC	
Freshwarer fish seed production and culture	1991-1995	Farmers	Semi-intensive culture of Indian carp	• RIA No. 1 • RIA No. 2 • Local fishery offices	
Production of seed and culture of economic freshwater fish in the south	1985-1995	Farmers	Supply of seed Culture technology	• RIA No. 2 • Local fishery offices	

Projects	Duration From/To	Target beneficiaries	Objectives	Implement. organiz.	Budget (in VN dong)
Production of industrial feed for shrimp culture		Farmers	Supply of pellet food for shrimp culture	• RIA No. 2 • SEAPRODEX	
Seaweed culture	1973-to date	Farmers	Culture technology Processing technology	• RIMP • Oceanographic Institute • Hanoi Univ. • Local fishery office	
Marine fish cage culture	1991-to date	Farmers	Culture technique of marine commercial fish Seed supply	• RIMP • Local offices	
Production of living food for larval stages of aquatic animals	1986-to date	Hatchery owners	Supply of living food organisms	• RIMP • RIA Nos. 1-3 • Fish Institute • Cantho Univ. • Local offices	
Extension	1994-to date	Farmers	Training of farmers	• Dept. Of Fish. Management • Extension offices (regional & local levels)	
Mekong Delta Master Plan	1990-to date	Farmers	Increased inland production	• WES program • AIT • RIA No, 2 • Cantho Univ.	• World Bank • UNDP • MRC
Formulation of policies and regulations	1991-to date	Farmers Managers	Management and sustainability in aquaculture	• Dept. of Fishery Management • Dept. of Resource Protection	

V. List of On-going Projects of Aquaculture development research organizations

Title of Projects	Duration From/To	Target beneficiaries	Expected outputs	Impementing organiz.	Budget (in VN dong)
Mixed shrimp-fishery model	1995-1998	Farmers Policy makers	Improved farming systems in the Mekong Delta	RIA No. 2 ACIAR	
Extension of aquaculture in the Mekong Delta	1997-2000	Farmers	Improved productivity	RIA No. 2 MRC	
Spawning and migration of Mekong fishes	1997-2000	Fishermen Policy makers Scientists	Baseline data for policy panning	RIA No. 2 Mekong River Commission	US$ 5m US$ 0.534
Wetland project for the Mekong Delta	1996-1997	Fishermen Policy makers Scientists	Guidelines and management systems for wetlands	RIA No. 2 MRC	150 m
Preservation of gene pool of fish species	1994-	Farmers	Pure lines of high quality fish species	RIA No. 1 RIA No. 2	VND300 m
Selection of common carp	1980-	Farmers	Fish seed production technology	RIA No. 2	VND500 m

Title of Projects	Duration From/To	Target beneficiaries	Expected outputs	Impementing organiz.	Budget (in VN dong)
Sex reversal of tilapia	1995-	Farmers	Male fingerlings	RIA No. 1' RIA No 2 Local fishery depts.	VND200 m
Prophylaxis and therapy of fish diseases	1995-		Methods for disease prevention and treatment	RIA No. 2 Inst. Of Vet. Science	VND200 m
Environmental survey on the Red river tilapia	1994-	Farmers	Data and information	RIA No. 1 Hanoi Univ	VND500 m
Rotation crops (fish-crab-shrimp) in brackishwater aquaculture	1996-	Farmers	Development of technology	RIA No. 1 Local fish. Depts. in coastal areas	VND200 m
Genetic improvement of farmed tilapia (GIFT)	1995	Farmers	Tilapia culture technology	RIA No. 1 ICLARM	
Integrated fish farming in the VAC ecosystem	1995			RIA No. 1 AIT	
Use of waste water in aquaculture	1995			RIA No. 1 AIT	
Cage culture in reservoirs	1996			RIA No. 1 AIT	
Shrimp culture in Nghe An province	1995			RIA No. 1 AIT	
Development of freshwater fishery in wet highland	1995-2001	Rural farmers	Development of technology	RIA No. 3 Mekong Delta	US$ 0.6m VND800 m
Institutional strengthening of aquaculture (project components are listed below)*	1995-1998	Mekong farmers	Strengthening of aquaculture	Cantho Univ. (trough the West-East-South Program) Fish Culture Research Institute (Hungary) ICLARM (for socio-economic studies)	US$ 2 m
Improvement of integrated farming in Mekong Delta	1995-1998	Farmers	Development of integrated farming	Cantho University Other depts of the University Mekong Rice Research Institute	
Study of Mekong catfish	1996-1999	Farmers	Increased production	Cantho University EU	
Shrimp seed and shrimp culture	1973-to date	Farmers	Increased production		
Shrimp seed supply for the north	1995-1996	Farmers	Supply of seed	FAO RIMP	
Mollusc production and culture (seed and culture technology)	1991-1996	Farmers	Develop crab production; increase productivity of mollusc	RCA No. 3 Province (Thanh Hoa) Central Aquaculture Com. Local fishery offices RIMP	

Title of Projects	Duration From/To	Target beneficiaries	Expected outputs	Impementing organiz.	Budget (in VN dong)
Seaweed culture	1973-to date	Farmers	Culture and processing techniques	RIMP Oceanographic Institute Hanoi Univ. Local fishery offices	
Living food for fish shrimp larvae	1986-1991 1996-2000	Hatcheries	Production of living food for shrimp, fish larvae; increased survival rate of larvae	RIMP RIA Nos. 1-3	
Seahorse	1995-1997		Preservation of seahorses	Inst. Of Oceanography Oxford Univ.	US$ 13,000

* The components of the project "Institutional strengthening of aquaculture" are:

- Improvement of breeding techniques and production quality of common carp in the Mekong Delta of Vietnam
- Evaluation of the quality of tilapia strains currently cultured in Vietnam
- Artificial propagation of indigenous fish species in the Mekong Delta
- Improvement of nutritional values of home-made feeds used for grow-out of economically important species
- Fish pathological survey at farms, practicing the most common integrated farming systems
- Improvement of sustainability of integrated farming systems in the Mekong Delta of Vietnam
- Impacts of agricultural intensification and expansion on aquatic organisms and environment in the Mekong Delta of Vietnam
- Identifying the technical manpower demand and research needs for aquaculture development in the Mekong Delta of Vietnam
- Identification of freshwater fish of the Mekong Delta of Vietnam
- Socio-economic studies

VI. List of the Research Organizations Responding to this Survey

1. Research Institute for Aquaculture No. I (RIA No. I)
2. Research Institute for Aquaculture No. 2 (RIA No.2)
3. Aquaculture Research Centre (RIA No. 3)
4. Institute of Oceanography
5. Research Institute of Marine Products (RIMP)
6. Department of Environment and Natural Resources, Cantho University

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